1990 ANNUAL REPORT

Alberta

OIL SANDS TECHNOLOGY
AND RESEARCH AUTHORITY

Alberta

OIL SANDS TECHNOLOGY
AND RESEARCH AUTHORITY

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TO HER HONOUR
HELEN HUNLEY
LIEUTENANT GOVERNOR OF THE PROVINCE OF ALBERTA

Madam:

I have the honour to submit the Annual Report of the ALBERTA OIL SANDS TECHNOLOGY AND RESEARCH AUTHORITY for the fiscal year ended March 31, 1990.

Respectfully submitted,

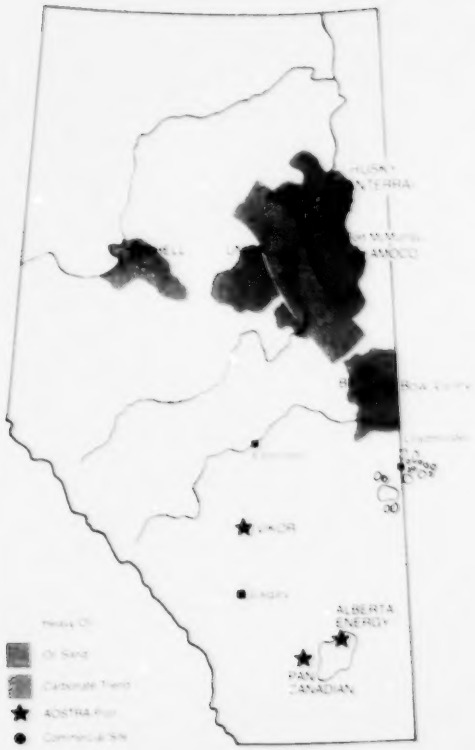
RICK ORMAN
Minister of Energy

Foreword

On January 14, 1974, The Premier of Alberta announced the availability of $100 million to develop new technology for the recovery and processing of petroleum from the Alberta oil sands. The terms and conditions for the disbursement of these funds are described in the Oil Sands Technology and Research Authority Act, passed by the Legislature in June 1974 and since amended to include the recovery of heavy oils and the enhanced recovery from conventional petroleum reservoirs. Additional funds have since been dedicated by the Alberta Government to permit the funding of longer term programs.

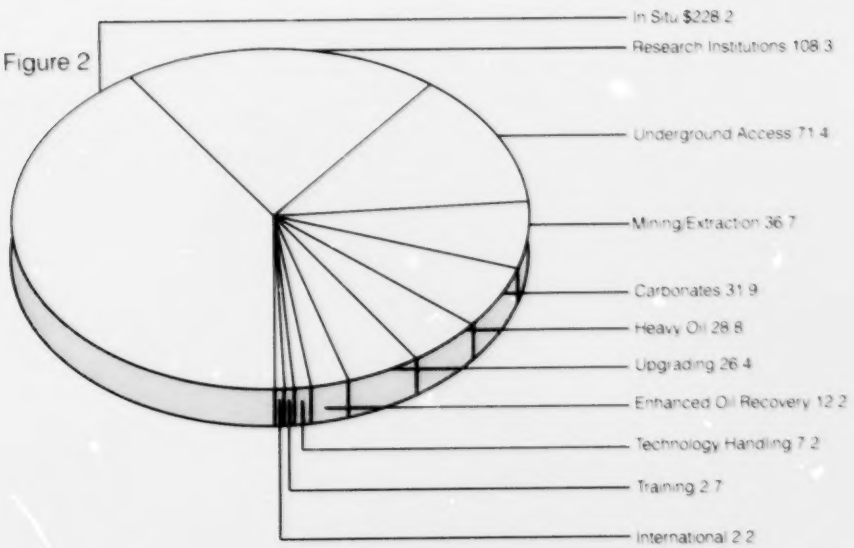
AOSTRA Field Pilot Projects

Figure 1



Commitments from AOSTRA Research Fund To March 31, 1990 ($ Millions)

Figure 2



Report of the Chairman and Chief Executive Officer

To the Honourable Rick Orman
Minister of Energy

Dear Mr. Minister:

I have the honour of presenting the Annual Report of the Alberta Oil Sands Technology and Research Authority (AOSTRA) for the fiscal year ending March 31, 1990.

During the past year there were several changes in Authority membership and also significant modifications to our organizational structure. Two long-standing Members retired from the Authority, Mr. Fred Kidd and Mr. J.E. (Bud) Miller. Both of these Members contributed greatly to the success of the Authority's activities through their extensive background experience and their commitment to making the Authority an effective and progressive organization. Mr. Kidd in particular had been associated with the Authority throughout its formative years, first as a representative of the Legislative Assembly, and then as a regular Member. Both will be missed. Authority Member Dr. Ernest J. Wiggins was appointed Acting Vice-Chairman on December 1, 1987, and resigned on April 15, 1990, but will continue his responsibilities as an Authority Member and Technical Advisor to the Chairman. In the two and a half years as Acting Vice-Chairman, Dr. Wiggins has contributed greatly to the success of AOSTRA. The Authority has also gained several new Members: Mr. Harry Alger, Ms. Camille Dow Baker, and Mr. Gordon Shrake, MLA. Further, Dr. Richard Luhning, the former Director of In Situ Operations, has been appointed as a Member and Vice-Chairman of the Authority for a three-year term. These new Members can be counted on to continue the dedicated efforts of their predecessors, as well as to bring fresh perspectives to the work of the Authority.

A key organizational change is the establishment of the new position of Director, Technology Transfer and Commercialization to reflect the increased priority and effort given to this area. In addition to the existing technology sales and commercialization program, all technical projects which have reached the demonstration stage will now become the responsibility of this Directorate. The creation of this new position will ensure that the necessary resources are made available to pursue effectively all commercialization opportunities. The position is being filled by Mr. Douglas P. Komery who has had a number of years experience in technology development and operations with a major oil company before joining AOSTRA four years ago.

Another addition to the organizational structure is the designation of Executive Directors for the Edmonton and Calgary offices of AOSTRA. In addition to his role as Authority Vice-Chairman, Dr. Luhning will serve as Executive Director (Calgary) with overall responsibility for technical and administrative operations in that office. Dr. David Redford will serve a similar function as Executive Director, Technical Programs and International Activities in Edmonton. The designation of these Executive Directors will strengthen coordination between the activities of the Edmonton and Calgary offices and will ensure the most effective use of available resources at both locations.

In its selection of projects for funding, AOSTRA will continue to emphasize the reduction of production costs, improvements in yields and efficiency, and minimization of the environmental impact of non-conventional oil production. Significantly increased priority will be given to projects which are in the final stages of the R&D process and are now ready for large-scale demonstration or commercial use. As examples, the horizontal well steam-assisted gravity drainage process pioneered in the AOSTRA Underground Test Facility near Fort McMurray has completed Phase A testing with results which exceeded expectations in terms of production rates, oil-steam ratios, and ultimate recovery. As a consequence of these favorable results, seven companies are now participating with AOSTRA in a Phase B prototype scale program which will test the performance of commercial-length wells and which could lead directly to a full-scale production operation at this site.

The AOSTRA Taciuk Process is continuing to attract industrial interest for a number of applications in addition to its original purpose of oil sands processing. A 240 tonne per day commercial unit has been built and sold by AOSTRA's industrial partner for hydrocarbon waste treatment applications in the United States, and Canadian applications in this field are being pursued actively by a licensee. Engineering work is being carried out in Alberta for a 6000 tonne per day processor for an oil shale application in Queensland, Australia. The developers of this resource are in the process of arranging financing for a shale oil production and refining operation. An agreement has also been reached to carry out small-scale tests on a Saskatchewan oil shale. In the oil sands field, negotiations are under way with a major integrated oil company for the use of the AOSTRA Taciuk Process for bitumen recovery at a large oil sands mining lease in Alberta. In this application, the AOSTRA Taciuk Process has the distinct advantages of

being economic in modular capacities and of producing clean, environmentally acceptable, dry sand tailings.

Negotiations are nearing completion with a consortium of oil sands leaseholders which could lead from the R&D phase into a major demonstration program using dredge mining and a cold water extraction process for bitumen recovery. The results of the laboratory and field pilot phases indicate that significantly lower production costs, accelerated water re-use, and simplified tailings disposal should be obtained. Other promising activities under this program which are still at the laboratory or field pilot stage are a modified hot water process for bitumen extraction and a borehole mining process for oil sands at intermediate depths.

AOSTRA's anti-water-coning technology ("AWACT") was an outgrowth of a heavy oil pilot project using in situ combustion. AWACT is now applied commercially in the Suffield heavy oil field operated by Alberta Energy Company. Following successful testing in a number of wells, this technology is now considered ready for commercial application in other reservoirs and is the subject of an active marketing effort. To date, over 50 companies have expressed interest in the technology and five field trials are under way.

Two other projects which are being evaluated for expansion to the commercial stage by AOSTRA's industry partners are the Vikor Joffre miscible carbon dioxide enhanced oil recovery project, and the Husky/Esso Kearl Lake project in the Athabasca oil sands. A study of the development potential of the AOSTRA Peace River Oil Sands Reserve has been carried out with a group of industry participants, and the possibility of initiating a pilot project is currently under consideration.

AOSTRA has participated with the Alberta Chamber of Resources and 17 of its member companies in the development of a business plan for the construction and operation of a regional upgrader. The main purpose of such an upgrader would be to accept raw bitumen and heavy oil from a number of smaller producers and enable it to be marketed as synthetic crude oil. The Regional Upgrader Business Plan identifies possible bases for joint industry and government involvement in this operation.

In addition to its strong emphasis on demonstration and commercialization of new technology, AOSTRA is continuing to increase its efforts in the environmental and international areas. Environmental aspects of the production and upgrading of oil sands bitumen and heavy oil have always been important factors in AOSTRA's process development programs, along with the usual considerations of costs, energy efficiency and yield. In light of the heightened public concern over the environmental impact of resource development, together with new areas of concern such as global warming, increased emphasis and prominence are being given to the environmental aspects of all of AOSTRA's activities. These include such diverse topics as reduction of atmospheric emissions, increased water re-use, production of tailings in a form suitable for early land reclamation and minimizing the disturbance of land surface and vegetation during production operations. Environmental audits now form a routine part of all in situ projects. With respect to the global warming issue, AOSTRA is studying means of minimizing carbon dioxide emissions at all stages from production through upgrading to eventual use as fuel, and has established a Global Warming Data Base in collaboration with Alberta Energy, Alberta Environment and the Alberta Research Council.

In the international area, petroleum producers and research organizations in many countries are becoming increasingly aware of AOSTRA's accumulated technology and expertise, and are approaching us with requests for assistance or with proposals for technology exchange. AOSTRA is pursuing these opportunities as actively as our resources will permit, since they not only offer benefits to AOSTRA in sale or exchange of technology, but also serve as a means of entry to overseas markets for Alberta equipment manufacturers, service companies, and consultants. AOSTRA works closely with Alberta Economic Development and Trade in promoting Alberta goods and services around the world, including active participation in trade shows and trade delegations.

Memoranda of Understanding or Letters of Cooperation have been signed with agencies in 20 different countries to date, and agreements have been implemented to cover such activities as resource evaluations, technology sales and exchanges, training of personnel, exchanges of specialists, joint sponsorship of seminars and membership in AOSTRA's University and Research Council Access program. Some interesting examples of technology sales opportunities are the use of the AOSTRA Taciuk Process for shale oil processing and hydrocarbon waste clean-up in China and the Soviet Union.

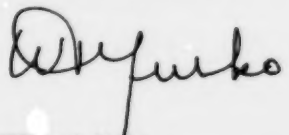
A continuing activity of international significance is AOSTRA's financial and technical support of the UNITAR/UNDP International Conferences on Heavy Crude and Tar Sands which are held every three years in different countries. The most recent Conference was held in Edmonton in 1988, with the next one to be held in Caracas, Venezuela. These Conferences bring together technical and production experts from all countries with an interest in non-conventional oil development, and serve as a valuable showcase for Alberta technology. Another important channel of communication with users worldwide is AOSTRA's own Library and Information Services ("ALIS") which maintains the most complete data base and hard-copy collection of oil sands information in the world and is used by researchers in all countries.

Mr. Minister, I have just touched on a few areas of AOSTRA's activities that are undergoing significant expansion at the present time. There are many other activities which are important to our continuing effectiveness, such as our institutional

programs at the Universities, the Alberta Research Council, the Petroleum Recovery Institute, the Computer Modelling Group and other organizations. These span a range from relatively basic research to highly applied research projects, and provide an essential foundation for the development of innovative technology in the future.

We are currently at an important but difficult stage in the evolution of Alberta's non-conventional oil industry. Unstable world oil prices inhibit major industry investment in new production capacity, and Canada is well on the way to becoming a major oil importer as conventional production declines. I believe that AOSTRA's most effective roles at this stage are: to find ways of minimizing production costs so that new projects can be viable even at today's oil prices, to make sure that environmentally sound technology will be available for a major expansion of Alberta's non-conventional oil production when economic conditions permit, and to develop opportunities for export of Alberta technology, equipment, and services to other countries. AOSTRA is fortunate in having a very capable technical staff, together with dedicated Authority Members who can provide sound policy guidance. With your continued support, I feel confident that AOSTRA can play its needed role.

Respectfully submitted,



William J. Yurko
Chairman and Chief Executive Officer

The Hon. Rick Orman and Members of the Authority
Standing: R.M. Allison, E.J. Wiggins, R.S. Aberg, J.M. Richardson, J.E. Miller
Seated: W.J. Yurko, The Hon. Rick Orman, G.W. Shrake

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Chairman
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Vice-Chairman
Dr. E. J. Wiggins*

Members
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Mr. R. M. Allison
Mr. F. A. Kidd†
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* Acting Vice-Chairman effective December 1, 1987
† Resigned March 1990

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Report of Activities

1 In Situ Oil Sands Recovery Program

1.1 AOSTRA Amoco Gregoire Lake Pilot Project

Amoco Canada Petroleum Company Ltd. with AOSTRA and Petro-Canada Exploration Limited as participants initiated operation of the Gregoire Lake in situ pilot project in 1984. The four-spot pattern of injection, production and observation wells is located on a site approximately 15 km northwest of the former Block 1 pilot. The project commenced operations in 1986 using steam and steam additives to recover bitumen from a 41 m thick McMurray sand reservoir located at a depth of 190 m. The first phase of the project was completed in 1989. The unique features of the project were that the initial heat front movement in the reservoir was tracked through the application of 3-D seismic monitoring over the pilot area and foam surfactants were injected to improve steam sweep efficiency.

An extension of the project was started in 1990 with Amoco and AOSTRA as participants. Further steam cycles and surfactant injection will be tested.

1.2 AOSTRA – Bow Valley – Cold Lake Pilot Project

Bow Valley Resource Industries Ltd. and AOSTRA operate a pilot in the Cold Lake area of northeastern Alberta to test the recovery of bitumen from the Clearwater formation. An inverted seven-spot pattern project was started in 1984 to test the use of superheated steam plus carbon dioxide and a clay stabilization additive for bitumen recovery.

A second inverted seven-spot pattern on larger spacing plus two special test wells were drilled in 1986 based upon the encouraging results of the first pattern. Operations in both patterns and the special test wells will continue throughout 1990. A third major expansion of the project is being planned to commence in late 1990.

1.3 AOSTRA – BP Marguerite Lake And B-UNIT Pilot Projects

The Marguerite Lake pilot project was located in the Clearwater sandstone formation of the Cold Lake oil sands deposit. The project was operated by BP Canada Exploration Ltd. with AOSTRA, Dome Petroleum Limited (now Amoco Canada Petroleum Company Ltd.) and PanCanadian Petroleum Limited as participants. The project, which started in 1978, tested steam stimulation followed by wet combustion. Later, five wells in the main pilot pattern were converted to oxygen injection to test oxygen combustion. This project was completed on March 31, 1987, and the steam and combustion technology is available for licensing. The steam recovery technology developed at the Marguerite Lake pilot is being applied in the Wolf Lake project which started in 1985 and surrounds the pilot area. BP is also planning to use the oxygen combustion technology in the Wolf Lake operation.

BP also operated the B-Unit pilot project with AOSTRA and Petro-Canada Inc. as participants in an area 10 km south of the Marguerite Lake project. The B-Unit pilot was a single well cyclic steam stimulation project in the Lower Grand Rapids formation of the Cold Lake oil sand deposit. The object of the testing was to improve bitumen recovery by novel fracturing/ injection methods initially developed at the AOSTRA-BP Marguerite Lake pilot. Based on the encouraging results of the B-Unit pilot, BP and Petro-Canada have commenced steam stimulation operations in a 22 well project producing from the Grand Rapids formation at a location adjacent to the Wolf Lake operation.

Cumulative oil production from the BP operations in Cold Lake exceeded 11 million barrels in early 1990.

1.4 AOSTRA – Husky/Esso Kearl Lake Pilot Production

Husky Oil Operations (formerly Canterra Energy Ltd.) is the operator of the Kearl Lake pilot project with AOSTRA and Esso Resources Canada Limited as participants. The pilot is testing a steam drive process in the McMurray oil sands and is located 77 km northeast of Fort McMurray. The formation is about 43 m thick at a depth of 150 m. The pilot consists of two patterns. The "A" pattern is an inverted seven-spot pattern with seven steam injection wells and six producers which were placed in operation in 1981. The "B" pattern initially consisted of an inverted nine-spot pattern which was designed based upon information from the "A" pattern. The initial "B" pattern started steam injection operations in 1985 and was expanded in 1987 with the addition of two adjacent inverted five-spot patterns. Special fracturing techniques were applied in the two new patterns and steam additives were also tested. A method for controlling steam outflow from the "B" patterns is under test. Production is expected to continue throughout 1990 from both the "A" and expanded "B" patterns. In November 1989, a production milestone was achieved when the cumulative bitumen production from the project surpassed one million barrels.

1.5 AOSTRA – Shell Peace River Pilot Project

Shell Canada Resources Limited operated the Peace River in situ pilot project with AOSTRA, Shell Explorer Limited (now Pecten Canada Limited)

and Amoco Canada Petroleum Company Ltd. as participants. The project, located 30 km northeast of the town of Peace River was designed as a prototype installation to test a modified steam drive recovery process in Peace River oil sands. The recovery technology is based upon a cyclic steam pressurization and modified drive in the 27 m thick oil sands at a depth of 550 m utilizing a 3 m bottom interval of high water saturation. In 1985, AOSTRA and Amoco ended direct participation in the project. In 1988 the fourth pressurization/production cycle was initiated with bitumen recovery now exceeding 55 percent from the pilot.

Using the pilot project technology, Shell Canada has constructed a commercial project with a bitumen producing capacity of 1600 m^3/day. Shell Canada reported that the Peace River project had produced a cumulative total of 10 million barrels of bitumen by February 1990. AOSTRA received data from the commercial project until October 1989.

1.6 AOSTRA – Unocal Buffalo Creek And McLean Pilot Project

Unocal Canada Limited, with AOSTRA and Canadian Superior Oil Limited (now Mobil Oil Canada Ltd.) as participants, operated the Buffalo Creek and McLean pilots which were located 100 km west of Fort McMurray. Starting in 1977, tests were conducted in the Grosmont 2 and 3 Devonian carbonate formations to determine the suitability of steam stimulation, steam drive and wet combustion processes for bitumen recovery. The program gave mixed results and the project was suspended in 1986 with analysis of field results continuing through 1989. AOSTRA is studying the potential of the carbonate area with the ultimate goal being the development of a new project in this large resource.

1.7 Data Base Management System

The AOSTRA Data Base System (ADBS II) provides entry, storage, reporting and retrieval of data collected by in situ projects. The system is used by project operators, project participants and AOSTRA internally. At the end of 1989, over 140 years of project data were resident within ADBS II, representing the detailed operations of 16 projects. Additional data from several projects is archived on tape, and may be used to create on-line data bases within ADBS II in future.

The ADBS II uses a relational data base management system and is maintained on a mini computer located at AOSTRA's Calgary office. Authorized users can access the system in "time-share" mode to access data from projects in which they are participants. In addition, the ADBS II software has been installed and licensed on computers located in the offices of project participants.

Features of ADBS II include use of menus to simplify entry of commands, fast response time to large volume data searches, standard query language for data manipulation, and a comprehensive report package customized for each project. The system is cost effective and "user friendly." AOSTRA Computer Service staff provide ongoing technical support and enhancements to ADBS II.

AOSTRA welcomes enquiries from Industry regarding the licensing of ADBS II for in situ projects.

2 Heavy Oil Recovery Program

2.1 AOSTRA – Alberta Energy Suffield Heavy Oil Pilot Projects

Alberta Energy Company Ltd. (AEC) operated the Suffield heavy oil combustion project on behalf of AOSTRA, Amoco Canada Petroleum Company Ltd. (formerly Dome Petroleum Limited) and Westcoast Petroleum Limited until the end of 1986. The fireflood was conducted in the Glauconitic sandstone reservoir under the Suffield military block in southeastern Alberta. Production from the combustion pilot was greater than would be expected by primary recovery alone. However, the combustion project was terminated in order to concentrate on an alternate recovery process that was identified during the combustion project. An anti-water coning technology (AWACT) was developed and tested by AEC, AOSTRA and Westcoast Petroleum in 1987 and 1988.

The process involves the injection of gas and a proprietary chemical formulation into wells which produce high water cuts due to water coning. Upon the resumption of production, oil production was significantly increased and water production dramatically reduced in many single well tests. The process was tested in a 20 m thick heavy oil reservoir underlain by water. The results of the AWACT tests were presented at a meeting with Industry members in June 1989. The process is now commercial and can be licensed from AOSTRA for application by interested companies.

An additional heavy oil recovery test was started in 1989 when AEC, AOSTRA and Westcoast Petroleum initiated a hot waterflood in an inverted four-spot pattern in the Suffield Block. Testing of the hot waterflood has been underway since August 1989, and will continue throughout 1990.

2.2 AOSTRA – Mazzei Frog Lake Field Pilot

In early 1990, AOSTRA initiated a project with Mazzei Oil Inc. as operator

in the Frog Lake area of east central Alberta. The project will test cyclic steam stimulation of the Mannville formation in the Lloydminster heavy oil sands. The reservoir is 3 m thick at a depth of 460 m. The results of the steam stimulation tests in two wells will be compared to the results of heating by electromagnetic methods in two adjacent wells.

2.3 AOSTRA – Norcen Bodo Field Pilot

Norcen Energy Resources Limited, on behalf of AOSTRA, Esso Canada Resources Limited (formerly Texaco Canada Resources) and Canadian Occidental Petroleum Limited operate the Bodo steamflood project in east-central Alberta. The results of the steamflood project will be compared with the results of an earlier combustion project operated until 1984 by Norcen in another area of the pool. The steamflood has a nine-spot configuration similar to the configuration of the offsetting combustion pattern. The test is being conducted in a McLaren sand in the Upper Mannville formation in a 15 m thick reservoir, located at a depth of 720 m. Since initiation of the steamflood in 1985, four cycles of steam injection have been completed. The cyclic steam injection is now being followed by a steamflood with continuing encouraging results. The steamflood will continue through 1990.

3 Technology Commercial Development

Close to one billion dollars has been invested over the past 15 years by AOSTRA and Industry towards development of new improved technologies for the extraction of bitumen from oil sands and improved recoveries of heavy oil in Alberta. Many of these more promising technologies are now ready for field demonstration towards commercialization.

AOSTRA's major effort towards encouraging industry to commercialize these new improved technologies when developing lease reserves, has been moved one more step ahead by the field demonstration of the following key projects.

3.1 Underground Test Facility (UTF)

The Underground Test Facility (UTF) project was initiated by AOSTRA in 1982, with a series of design studies employing mine access to provide for effective testing of horizontal well in situ recovery processes. These studies led to a commitment to the construction of the UTF in 1984.

During 1985, an industry steering committee, with representatives from 16 firms interested in the UTF concept, worked with AOSTRA in a further major study to confirm project feasibility and identify a preferred priority of processes for field testing. During this period, work continued on the mine construction and on the development of a custom drilling rig designed to place long horizontal wells from the underground tunnel system.

The results of the steering committee study indicated good potential for the project, but industry conditions at the time could not support immediate participation in a major heavy oil pilot. In early 1986, AOSTRA made a further commitment to limited Phase A testing of the preferred candidate, the steam assisted gravity drainage (SAGD) process. By the end of that year, the mine access facilities were complete and the custom drilling rig had been fabricated, field tested and re-assembled down the mine ready for drilling of the test wells.

Successful organizational and developmental activities led up to the in situ process testing in 1987. Six Canadian industry majors (Chevron, Texaco, Mobil, Petro-Canada, Shell and Amoco) and CANMET, the Canadian Centre for Mineral and Energy Technology of the Department of Energy, Mines and Resources Canada, became participants in the Phase A program. Enhanced geotechnical work and a separate test of Chevron's proprietary HASDrive process were added to the program. Successful, underground drilling tests resulted in the placing of eight horizontal wells, with significant advances in the technology. By November 1987, all facilities were complete, including the additional HASDrive wells and equipment, and both process tests were into start-up.

Over the past two years, both Phase A tests have been unqualified technical successes, and the SAGD process has demonstrated a commercially viable combination of production rates, steam/oil ratios and ultimate recovery. These results fully justified expansion to the Phase B SAGD test, which was designed to confirm that the necessary drilling accuracy and scale up in performance is achievable over a commercial well length.

After approval by AOSTRA and seven industry participants (Chevron, Esso, Mobil, Petro-Canada, Shell, Amoco and Conoco), Phase B construction commenced in the spring of 1990, with the drivage of 500 m of new tunnel. Drilling of the new horizontal wells from the new tunnels is planned to start in mid-1990. The Phase B test consists of three pairs of horizontal wells with completed lengths of 500 m and a 70 m spacing between well pairs. Steaming of the first well pair is scheduled to begin early in 1991 and the test is expected to last four to five years, reaching an overall peak bitumen production rate of about 2000 BPD.

3.2 AOSTRA Taciuk Process (ATP)

Approximately 19 million dollars has been invested by AOSTRA over the past 12 years towards commercial development of the ATP. The processing of over 15,000 tonnes of oil sands, oil shales and hydrocarbon bearing waste soil material in the AOSTRA-owned pilot in Calgary, and scale-up development testing during this period, has provided confirmation of the successful performance of the ATP.

The ATP is ready for field demonstration in the extraction and primary upgrading of bitumen from mined oil sands in Alberta. AOSTRA's main objective in continuing discussions with Alberta oil sands lease holders is aimed at encouraging industry to field demonstrate the ATP technology, as part of the planning process towards commercial development of Alberta bitumen reserves.

The other two applications of the ATP technology being pursued are the processing of oil shales and the treatment of hydrocarbon bearing soil materials.

3.3 ATP Application In Processing Oil Shales

Over the past 12 years, Southern Pacific Petroleum N.L. (SPP) and Central Pacific Minerals N.L. (CPM) of Australia, have investigated 15 oil shale extraction technologies developed in five countries. They have found the ATP to be the most technically and economically viable process for the extraction of oil from oil shales.

Due to successful results of processing 1500 tonnes of the Australian Stuart Deposit oil shale in AOSTRA's 105 tonnes per day Calgary pilot during 1987 and further scale-up testing, technical and economic assessments during 1988 and 1989, SPP/CPM have undertaken to work towards construction of a 6000 tonne per stream day semi-commercial oil shale demonstration plant in Queensland, Australia. Start of construction is expected as soon as project financing is secured by SPP/CPM.

AOSTRA's formal agreement with SPP/CPM ensures that the prime engineering of the ATP system and construction of the processor will be conducted in Alberta. It also allows for AOSTRA's participation in the performance testing of the demonstration plant, and AOSTRA ownership of all new processing, mechanical and scale-up technologies gained from such field operations. Hence, AOSTRA will be able to incorporate these new experiences into larger ATP systems for Alberta oil sands applications.

3.4 ATP Application In The Treatment Of Hydrocarbon Bearing Soil Materials

The application of the ATP technology in this field is considered commercial. In 1988, AOSTRA granted UMATAC Industrial Processes of Alberta, a Division of UMA Engineering Ltd., an exclusive license for commercial application of the ATP in the field of treatment of hydrocarbon bearing soil materials in North America. This included the ability for UMATAC to grant sub-licenses for such purposes to third parties.

UMATAC and Canonie Environmental Services Corp. of Porter, Indiana, formed SoilTech Inc., which was sub-licensed to commercially use the ATP technology for remediation of hydrocarbon contaminated soil materials in the United States.

Late in 1988, SoilTech Inc. purchased from UMATAC, at a cost of $4.5 million (Canadian), the first commercial ATP plant of this type. The 240 tonne per day transportable ATP plant was constructed by UMATAC in Alberta during 1989, and was successfully performance-tested at AOSTRA's Calgary ATP pilot site. The ATP plant is planned to be used initially by SoilTech Inc. to recover polychlorinated biphenyls (PCB's) and associated oils from Waukegan harbor in Illinois and for soil remediation at Wide Beach, near Buffalo, N.Y.

During 1989, UMATAC and ADS Engineering of Montreal, formed a new Canadian company, ADSUMA Inc. ADSUMA Inc. is the first Canadian licensee of the ATP technology for treatment of waste materials containing mixtures of hydrocarbons, water and soils. ADSUMA Inc. has prepared proposals to potential clients, such as Alberta firms, major oil companies, utility companies, and other provincial agencies, for oil recovery from drilling muds, oil field production wastes, coal tar contaminated soils, and oil contaminated soil in reclaimed harbor sites, abandoned refinery sites and petrochemical plants.

Commissioning ceremonies for the 240 tonne per day ATP system were conducted on August 21, 1989, attended by the Chairman of AOSTRA, the Alberta Ministers of Energy and Environment, and by representatives of Industry.

AOSTRA's licensing of UMATAC provides for royalties to be paid to AOSTRA for commercial application of the ATP technology in this field.

3.5 Technology Sales

Over the past 15 years, AOSTRA has effectively implemented the research and field demonstration of new improved technologies towards commercial development of Alberta's oil sands and heavy oil resources. To commemorate this notable milestone, a "15 Year Portfolio of Achievement" was published. This book provides industry, government agencies, research institutions and others an understanding

of AOSTRA's functional organization and level of development of key technologies as well as an overview of AOSTRA's history.

The financial highlight of the fiscal year ending March 31, 1990, was the execution of 23 technology licensing agreements and Underground Test Facility (UTF) participants' agreements with a combined value of $8,188,000. An additional seven agreements are pending. The number and value of these licensing agreements is indicative of interest by industry in AOSTRA technology as it develops from institutional research and experimental field projects into commercially viable applications. In addition, AOSTRA entered into over 80 agreements with industries who wished to examine reports or technology packages, in confidence, for potential purchase.

The wide range of AOSTRA technology covering mining, bitumen extraction, upgrading, in situ recovery methods and institutional research was highlighted at the AOSTRA Oil Sands 2000 Conference in Edmonton in March 1990. An AOSTRA technology display made a significant impact on delegates' awareness of technology available from AOSTRA. The display is now available for other conferences to further promote AOSTRA technology.

Another significant event involving technology transfer and commercialization was the publication of the July 3, 1989 issue of Oilweek, which featured the technological and scientific accomplishments of AOSTRA.

Included within the issue, which was distributed to Oilweek's 15,000 subscribers, was the "AOSTRA Advanced Oil Recovery Technologies" wall chart. The wall chart has been received favorably by industry. A planned overprint of 20,000 allowed the distribution of wall charts to schools across the province. International acclaim has warranted the printing of the chart in Chinese. Plans have been made to print the wall chart in the Russian and Spanish languages.

3.6 AOSTRA Data Base System (ADBS II) – Technology Transfer And Commercialization

AOSTRA has available a new state of the art data base system (called "ADBS II") for management of data collected by in situ projects.

ADBS II provides storage, reporting, retrieval and manipulation of data in a manner that is both cost effective and "user friendly." The system is capable of generating numerous reports, both preformatted and "ad hoc," to support all functional areas of project operation. Reports generated include formats suitable for reporting to the Alberta Energy Resources Conservation Board. In addition, all historical data can be accessed to assist with project monitoring and evaluation.

Licensing ADBS II

The ADBS II is part of AOSTRA's technology marketing and transfer program. Agreements for use of the system are available in the following areas:

- License for use of the ADBS II on the user's own computers. In this case, AOSTRA installs and supports a customized version of the software on the user's own system. Costs are negotiated on a project basis.
- Access to pilot project data stored on AOSTRA's in-house computer via ADBS II. Users must be participants in the project (i.e. operator, partner or consultive participant) for the particular data accessed, since all data within ADBS II is confidential.

Major Activities

The major technology transfer activities are summarized as follows:

- Execution of the sales agreement between AOSTRA and Petro-Canada Inc. for the license use of the Wolf Lake In Situ Oxygen Combustion Project technology for $3,825,000;
- Continued industrial support of the Underground Test Facility consultive participant program, for a value of $4,050,000;
- Emergence of the anti-water coning technology (AWACT) with three wells now treated outside the Suffield Heavy Oil Project and 15 more wells in five different reservoirs, scheduled for treatment in 1990;
- Sale of 23 technology reports for a combined value of $73,000;
- Licensing of the AOSTRA ADBS II to Petro-Canada Inc. The AOSTRA Data Base System (ADBS II) is a computer data base for management of data collected by in situ projects. The license included incorporation of two in situ projects' data bases and the installation of workstations in 16 company offices. The ADBS II system is utilized by project participants on seven other active AOSTRA/Industry projects.
- Growth in the membership of the AOSTRA University Research Industry Access Program and the AOSTRA/ARC Industry Research Program in Advanced Thermal Recovery;
- Licensing of the AOSTRA Taciuk Process (ATP) for use in waste treatment in the United States and Canada and continued activities and progress toward the commercial application of ATP for recovery of oil from oil shales and the recovery of bitumen from Athabasca oil sands.

4 Enhanced Recovery Program

4.1 AOSTRA – Amoco Cessford Caustic Polymer Flood

Amoco Canada Petroleum Company Ltd. operates the Cessford caustic polymer flood with AOSTRA and Esso Resources Canada Limited as participants. The test is being conducted in the Cessford Colorado "A" Pool which is approximately 180 km east of Calgary.

Single well tracer tests and further laboratory tests indicated that oil recovery could be improved with a caustic-polymer flood which was initiated in 1986. The gross costs for the incremental caustic-polymer waterflood were estimated to be $4.9 million. The project is ongoing with the chemical slug injection expected to be completed in 1990.

4.2 AOSTRA Anti-Water Coning Program

In 1988, AOSTRA initiated a study of methods of preventing water coning, particularly in heavy oil reservoirs underlain by water which are common in eastern Alberta. Different methods of anti-coning are being investigated including the anti-water coning technology (AWACT) developed by AOSTRA, Alberta Energy Company Limited and Westcoast Petroleum Limited, and microbial techniques. A number of evaluations of suitable field candidates for AWACT testing have been conducted along with the design of AWACT field treatments. Laboratory tests are being conducted to determine the suitability of using microbial techniques for anti-water coning in two potential candidate fields.

4.3 AOSTRA Canadian Hunter Ethel Lake "BHL" Pool Horizontal Well

In 1988, Canadian Hunter Exploration Ltd. with AOSTRA as a participant drilled a long radius horizontal well into the Ethel Lake "BHL" pool. In this area where vertical wells have proven non-commercial, the purpose of the test was to assess the commercial feasibility of exploiting low permeability oil bearing carbonate reef reservoirs with horizontal wells. The well was successfully drilled and the potential of the well is being assessed.

4.4 AOSTRA – D.B. Robinson Industry Slim Tube Study

AOSTRA is the operator of a cooperative multi-client industry supported research program to investigate the use of slim tube tests to evaluate conditions of miscibility in miscible floods. The program is financially and technically supported by 10 industries and D.B. Robinson and Associates Ltd. is the contractor for the project.

The objective of the program is to demonstrate the feasibility of collecting and analyzing small samples of flowing fluid in a slim tube in the transition zone between the solvent and the oil. Special slim tube test equipment was designed and fabricated for the project. The series of slim tube tests is now being completed.

4.5 AOSTRA Gulf Fenn – Big Valley "D-3B" Nitrogen Injection Project

A nitrogen injection project in the Fenn-Big Valley "D-3B" pool is operated by Gulf Canada Resources Ltd. with AOSTRA as a participant. The project is located approximately 80 km east of Red Deer. The project was initiated in 1987 with the injection of nitrogen into a small Devonian reef reservoir to determine if the recovery of oil, natural gas liquids, sulphur and gas could be improved by the maintenance of reservoir pressure, replacement of reservoir fluids by nitrogen and the stabilization of fluid interfaces. In 1989, the project was extended to test the effectiveness of injection of nitrogen foam in further enhancing recovery.

4.6 AOSTRA – Husky Asphaltene Solids Precipitation Project

Husky Oil Operations Ltd. (formerly Canterra Energy Ltd.) and AOSTRA jointly supported a laboratory research program to study the precipitation of asphaltenes in selected light oils when contacted by hydrocarbon fluids. Husky operated the project which was conducted by Hycal Energy Research Laboratories as contractor for the project. A mathematical model was formulated using an equation of state and data obtained from asphaltene solubility tests to predict the deposition of asphaltenes under variable pressure and temperature conditions. The study was completed in 1990 at a cost of $310,480. A PC computer program was developed for the prediction of asphaltene precipitation based upon the mathematical model.

4.7 AOSTRA – Mungan Petroleum Enhanced Oil Recovery Book

The publication of a book on enhanced oil recovery by chemical and miscible methods is being supported by AOSTRA. Dr. Necmettin Mungan of Mungan Petroleum Consultants is writing the book which will include a state of the art description of various recovery methods such as polymer, alkaline, surfactant and miscible flooding. Chapters on residual oil saturation, wettability, interfacial tension and pilot testing in the field will be contained in the book.

4.8 AOSTRA – PanCanadian Countess "B" Combustion Pilot Project

PanCanadian Petroleum Limited and LL & E Canada Limited are partners in

a wet combustion recovery process which is being evaluated in the Countess Upper Mannville "B" pool. The project, which was initiated in 1982, is located near Brooks and is being operated by PanCanadian. Field operations continued into 1990 with encouraging results. An expansion of the project is planned for late 1990.

AOSTRA funds and operates a research program to support the pilot activities. The supporting research program will continue through 1990 and has included combustion tube tests, geological studies, emulsion treating studies, corrosion studies, combustion front mapping, a post combustion core well, numerical simulation modelling, a production sampling well and core flow tests for process evaluation.

4.9 AOSTRA – Pfizer Profile Modification Study

Pfizer Canada Inc. is the operator of a project with AOSTRA to field test the modification of injection profiles in injection wells in waterfloods by injecting a gelant slug into highly permeable thief zones. The demonstration of the effect of improved injection profiles in volumetric sweep and ultimate recovery is the goal of the project. Negotiations have been initiated with field operators to identify suitable field candidates and to conduct the field tests. It is anticipated field testing will be started in 1990.

4.10 AOSTRA – Vikor Joffre Viking CO_2 Miscible Flood

Vikor Resources Ltd. operates the Joffre Viking CO_2 miscible flood on behalf of AOSTRA and the unitization participants in the project. The project is located in central Alberta approximately 20 km northeast of Red Deer and is the first miscible CO_2 flood to be conducted in Canada.

CO_2 injection commenced in 1984 in a previously waterflooded and abandoned segment of the Joffre Viking (lower Cretaceous) sandstone reservoir. The initial pilot consisted of two adjacent five-spot patterns. The pilot demonstrated the ability of CO_2 to recover tertiary oil from a 3 m thick reservoir containing light gravity oil using CO_2 injection alternating with water injection for mobility control. The encouraging results of the pilot led to two commercial expansions, one in 1985 and one in 1988. A mobility control test using a foam surfactant was initiated in the original pilot area in 1988. Production in the original pilot area and the two expansion areas will continue through 1990.

4.11 AOSTRA – Ulster Petroleums Retlaw Upper Mannville "B" Immiscible CO_2 Project

The first immiscible CO_2 project to be conducted in Canada is operated by Ulster Petroleum Limited (formerly Canadian Westgrowth Limited) in the Retlaw Upper Mannville "B" Unit on behalf of the Unit participants. The project is located 30 km northeast of Lethbridge. The objective of the project is to evaluate the performance of a CO_2 immiscible flood in a water sensitive reservoir. The injection of CO_2, which commenced in 1983 is being followed by water injection.

The operating data on the project are being acquired by AOSTRA for analysis of the performance of the project.

5 Engineering And Technology Development

5.1 Alpha Engineering – Cyclic Steam Analytical Model

Cyclic steam stimulation analytical models for vertically and horizontally fractured reservoirs were developed by Alpha Engineering. These models are being validated by history matching actual field data. AOSTRA is one of six participants each committed to $6,250 for the project.

5.2 Centre for Frontier Engineering Research

AOSTRA continues to actively participate in and fund CFER core programs at $25,000 per year. Progress continues to be excellent in programs including wear problems in oil production wells, tubing joint integrity, casing formation interaction and sucker rod-tubing wear. A new project concerning slant well directional control and costs was initiated in late 1989.

AOSTRA also participates in a study to qualify Grade 55 casing for thermal recovery wells. This study is expected to be completed this year at an AOSTRA cost of $30,000.

5.3 Computer Modelling Group – Thermal Well Simulator (THEWS)

Injection and production mode testing of the Thermal Wellbore Simulator (THEWS) program jointly developed by CMG and AOSTRA continued. The fully transient finite element wellbore heat loss model is proving very valuable in analyzing thermal wellbore performance. The THEWS model was coupled to the Steam Additive Reservoir Simulator (STARS) model for horizontal well application and is at the stage of testing with field data. A thermal dual porosity dual permeability numerical reservoir simulator is being developed. AOSTRA expenditures in the 1989/90 fiscal year have been $220,000.

5.4 Fekete – Thermal Well Test Package

An IBM PC based computer program to analyze thermal well tests was developed by Fekete Associates Ltd.

and subsequently tested by AOSTRA and approved for release to industry. Total AOSTRA financial support to the project was $80,000.

5.5 Poon Consulting – Horizontal Well Production Forecast Model

AOSTRA, in partnership with Esso Resources Canada Limited, supported the development of an analytical model for forecasting the production performance of a horizontal well in a homogeneous infinite reservoir of constant thickness by D.C. Poon Consulting Inc. The model and dimensionless type curves generated by the model were completed. AOSTRA expenditure on this effort was $10,000.

5.6 Simtech – Oil Sands Fracturing

AOSTRA has continued to fund and actively participate in a joint industry plus Energy, Mines and Resources Canada (CANMET) funded project, to develop geomechanical stress strain finite element models. The final phase of the project to combine all work to date into a comprehensive modular modelling system for oil sands engineering was initiated in April 1990 and is expected to be completed in 1991. AOSTRA funding for this final phase is $10,900.

5.7 Simtech – Flow Through Perforations

AOSTRA is participating in a joint industry project, studying the geomechanical effects and flow through perforation completions in sands. Physical laboratory perforation tests were modelled and a field model describing perforation effects and wellbore inflow considerations is nearing completion. Anticipated delivery of a tested model is July 1990. AOSTRA contribution to the project is $20,000.

5.8 Maurer – Horizontal Well Technology

AOSTRA's participation in a consortium, consisting of 90 participants from 13 countries, supports a project being conducted by Maurer Engineering Inc. of Houston, Texas, to develop and evaluate horizontal drilling, completion and production technology. Numerous technical reports, case studies and analytical models which provide a strong technical base for horizontal well technology, have been developed. Phase I of this project, which involved an expenditure of $35,000 (U.S.) by AOSTRA, will be completed in 1990. A Phase II, to extend this technology further, particularly in the completion and operations aspects and costing $35,000 (U.S.), has been proposed.

5.9 TDC – Foamflood Simulator

Development of a foamflood simulator by TDC Reservoir Engineering Services, is being supported by AOSTRA and six other industry participants. The project, initiated May 1989, developed a one-dimensional model for scoping purposes, and is developing a numerical model to simulate foam flooding. AOSTRA's share of the current phase, expected to be completed in June 1990, is $30,000 (U.S.).

5.10 Simons Consulting Services Coning Project

An engineering design study, conducted by Simons Consulting Services Ltd. to assess the feasibility of a novel method to reduce the effects of water coning in oil wells, initiated in September 1988, was completed in July 1989. The concept was determined to be feasible.

A second phase, the selection of a test well and the design and field test of the concept is in progress. AOSTRA expenditures for this project total $96,200 to date.

5.11 AOSTRA Peace River Task Force

A task force, consisting of AOSTRA and four industry participants, was established in May 1989 to evaluate the development potential of the Peace River Oil Sands reserve area. A comprehensive review of public domain information for the Shell Peace River project concluded that the reserve lands have development potential. Additional work, including conducting seismic and possibly delineation drilling on the reserved lands, was recommended. Expenditures to date totalled approximately $56,000.

5.12 AOSTRA-Industry Thermal Well Pump Program

An AOSTRA-Industry Thermal Well Pumping Steering Committee was formed in September 1989. During the 1989/90 fiscal year, AOSTRA, the Alberta Research Council, 11 participating oil companies, and three pump manufacturers, reviewed past work sponsored by AOSTRA, addressing thermal well pump performance and developed a joint program for the 1990/91 fiscal year.

5.13 In Situ Engineering Support Program

A program, to support in situ engineering, established in 1987, enables AOSTRA to conduct studies to develop an understanding of various new technologies and support field application, marketing and technology development efforts. Specific studies and activity supported by this program in 1989/90 include:

- Additive Anti-Water Coning — continued to develop an understanding of the technology and presented it to industry.
- Aquathermolysis — tested ferrie salts and time and temperature effects on aquathermolysis with

Alberta Sulphur Research Ltd. at PRI.

- Grosmont — reviewed pilot test results to date, conducted additional geological assessments and made preliminary contact with industry to promote development of the Grosmont resource.
- Microbial Application — coordinated and directed laboratory tests at the Petroleum Recovery Institute of microbial applications in controlling water mobility and designed a test for the Bantry field.
- Public Data — reviewed data now in the public domain for approximately 60 pilot projects and identified technology transfer potential for the data.

Expenditures in this program total approximately $114,000 in the 1989/90 fiscal year.

5.14 In Situ Site Studies Program

The AOSTRA in situ studies program funds geological and other studies supporting AOSTRA projects and potential projects. Activities during the 1989/90 fiscal year included:

- Geological studies in the Lindbergh and Grosmont areas.
- A study of geological factors controlling steam placement in a number of AOSTRA pilot projects.
- Anti-Water Coning Technology (AWACT) application designs for prospective candidates provided by Industry.

Expenditures in this program total approximately $56,000 in the 1989/90 fiscal year.

6 Produced Water Recycling Program

Since the late 1970's, AOSTRA has been actively involved in research dealing with water which is co-produced with bitumen and heavy oil from in situ recovery operations. Because of a limited supply of fresh water, it is desirable to recycle any water that may be recovered, rather than dispose of it completely as production waste. The recycling of produced water to meet steam generation requirements offers two significant environmental advantages; it reduces the consumption of fresh water resources, as well as reducing the volume of wastewater requiring deep well disposal.

"Produced water" contains several impurities which must be removed, if this water is to be re-used as feed to a steam generator. The quality of the water produced with the heavy oil at an in situ recovery operation varies widely from one geological formation to another within Alberta. Produced waters in Alberta have been roughly classified according to total dissolved solids (TDS) levels. Waters produced from the Peace River deposit typically have low TDS (< 8000 mg/L). Cold Lake area produced water falls into a category of moderate TDS (8000 to 17,000 mg/L). Lindbergh area produced waters, however, are very high in TDS (17,000 mg/L and up).

AOSTRA's participation in the area of produced water treatment is crucial to advancing the state of knowledge of this critical issue, as well as the development of technologies and methods which can be commercialized for use in operating facilities.

6.1 AOSTRA/Environment Canada/Industry – Lindbergh Area Produced Water Treatment Project

In order to treat the produced water in the Lindbergh area for reuse as feed water for steam generation, it is important to reduce the total dissolved solids (TDS). TDS removal can be achieved in processes such as electrodialysis, reverse osmosis, vapor compression evaporation and freeze desalination. Many of these technologies are currently not economically feasible.

In 1986, AOSTRA, Environment Canada, Amoco Canada Petroleum Company Ltd., Dome Petroleum Limited, Murphy Oil Company Ltd., PanCanadian Petroleum Limited and Westmin Resources Limited initiated the first phase of a project to test treatment processes for high TDS produced waters.

In Phase I of this project, the efficiency and operating characteristics of a vapor compression evaporator (VCE) for TDS removal were tested. Pilot testing of the VCE at Murphy's Lindbergh Thermal Project commenced in 1987 and was completed in 1988. Results of the pilot test demonstrated that TDS removal by evaporation is technically achievable. However, pre-treatment of the VCE feed would be necessary to stabilize the characteristics of the water. This rendered the treatment more expensive than originally anticipated.

The total project cost of Phase I was $875,000 with AOSTRA's share being $375,000. The technical reports for Phase I have been listed in AOSTRA's Catalogue of Technology and Services (1990/91 price list) at a cost of $36,000.

Based on the costs estimated for vapor compression evaporation, developed in the Phase I report, as well as preliminary cost estimates for electrodialysis developed by Environment Canada, a Phase II program was proposed to assess the economic feasibility of using membrane technology. Although the VCE process evaluated in Phase I was technically the most advanced of all the TDS removal technologies, the fact that pre-treatment was now considered necessary, suggested that electrodialy-

sis, while not proven to the same degree as VCE, may offer potential cost advantages. Consequently, the Phase I participants (with the exception of Dome Petroleum Limited) approved the second phase of the project to test electrodialysis as a process for TDS removal.

The Part 1 portion of Phase II consisted of the field testing of two membrane technologies, ultrafiltration and micro-filtration, as pre-treatment alternatives for suspended oil and solids removal. This testing took place at the Amoco Elk Point Pilot Facility. In addition, Part 1 of Phase II included successful bench scale testing of an electrodialysis unit. The cost of Part 1 of Phase II was $188,000 with AOSTRA's share being 50% or $94,000. The cost of Part 2 is projected to be $462,000, with AOSTRA's share being $231,000. The total Phase II costs to AOSTRA will be $325,000

Based on the results of Part 1, the management committee has elected to proceed to Part 2 of Phase II. The proposed field pilot work under Part 2 will be conducted at the Amoco-Elk Point site. The first part of the work will involve the construction of a pilot scale, continuous flow electrodialysis (E/D) unit. The second part of the work will involve pilot testing of the electrodialysis process, with field testing beginning in the fall of 1990. Produced water feed to the E/D unit will be pre-treated by passing it through a micro-filtration membrane (selected from Part 1 work) for removal of suspended solids and oil and grease. The E/D unit will be a custom-made unit for high temperature produced water application.

6.2 AOSTRA/CANMET/ Monenco Thermal Lime Softening Process Development

Presently, the only commercially available technologies for the reduction of hardness and silica in produced waters are the Hot Lime and Thermal Softening processes, such as those being used by Esso Resources Canada Limited at Cold Lake. The disadvantages of Hot Lime Softening are its relatively high capital costs and production of large quantities of lime sludge, which require disposal. In addition, depending on the influent silica concentration, neither process may adequately reduce silica content to acceptable boiler feedwater concentration.

In 1988, AOSTRA joined with Monenco Consultants Limited, Energy Mines and Resources Canada (CANMET) and Supply and Services Canada to investigate and test a Thermal Softening process, which incorporated magnesium sulphate addition for silica removal (in a single reactor). Phase I of the project involved bench scale testing of the process in batch equipment. The results indicated that the process should be able to reduce silica and hardness to boiler feed specifications within 10 – 30 minutes. Consequently, it was decided that there was sufficient evidence to support testing the technology at a continuous flow pilot scale. The cost of Phase I was $115,254 (AOSTRA's share being $57,627) and the final report was received in June of 1989.

It is anticipated that the necessary documentation will be in place shortly to allow Phase II to proceed in the third quarter of 1990.

7 Surface Mining/ Extraction Program

7.1 AOSTRA Taciuk Process

The AOSTRA Taciuk Process (ATP) has been developed in conjunction with UMATAC Industrial Processes, a Division of UMA Engineering Ltd., for the simultaneous extraction and primary upgrading of bitumen from mined oil sands. The ATP is a thermal retorting process which accepts run-of-mine oil sands feed and produces cracked petroleum distillates; dry, oil-free tailings; off-gas, and process waters. The principal process operations occur in a single, horizontal rotating vessel, called the processor, which together with auxiliary equipment to recover products and effluent wastes, make up the ATP system.

The development of this technology, which has proceeded without interruption since 1977, has been funded entirely by AOSTRA at a cumulative cost of approximately $19 million.

The AOSTRA-owned 105 tonnes/day continuous flow pilot plant in Calgary has processed successfully over 12,000 tonnes of oil sands and other candidate feeds. This operating experience has confirmed the operational and performance characteristics of the ATP and has led to improvements in mechanical design and the development of scale-up criteria.

Since 1984, the ATP has been ready for scale-up. A field demonstration plant would be an essential intermediate step in preparation for a full scale oil sands commercial plant. Over the past two years, AOSTRA has been discussing with lease holders the possibility of participation in a large scale field demonstration plant.

The ATP has been shown to be an effective method for recovery of liquid hydrocarbon from oil shales. Under an agreement between AOSTRA and Southern Pacific Petroleum (SPP) of Sydney, Australia, SPP is continuing to develop its plans to build and operate a semi-commercial 6000 tonne per day oil shale demonstration facility in Queensland. Under a contract with SPP, UMATAC is completing a detailed

design basis memorandum, which SPP will use to support their program for obtaining financing for the project.

The ATP has shown potential to treat other hydrocarbon bearing and organic solids such as municipal and industrial wastes, rubber and plastic products.

To evaluate this potential, a jointly funded project, involving AOSTRA, the Alberta Research Council, Alberta Environment, and Alberta Technology, Research and Telecommunications, is being planned to test the ATP for pyrolysis of municipal solid waste. The first phase of this program will examine the processability of a 50 tonne sample of compacted, extruded municipal waste on the 240 tonne/day unit followed by a program of batch tests. If the tests are successful, an engineering study and cost analysis will be undertaken.

The development of the ATP is continuing with focus on design improvements. One such area of focus is the Flue Gas Desulphurization system where a new program has been initiated to test an improved novel method of sulphur capture. The test program will continue in the coming year.

7.2 OSLO (Other Six Leases Operation) Dredge Mining And Cold Water Extraction Development Project

AOSTRA and the partners in OSLO have funded the first three years of a multi-year project, on a 50–50 basis, to test and evaluate the use of suction dredges to mine oil sands and to develop a compatible Cold Water Extraction Process. It is believed that this approach may significantly reduce the overall cost of bitumen production from mined oil sands.

The overall project is a phased seven-year program which will ultimately cost approximately $69 million and which would culminate in a field demonstration of a semi-commercial sized dredge/extraction facility.

The first year (1987/1988) program, approved by AOSTRA and OSLO at a cost of $900,000, consisted of laboratory based testing of the Cold Water Extraction Process; design, construction and operation of a laboratory sized pilot dredge; oil sands slurry pumping and dispersion tests; and a feasibility study for field testing of the pilot dredge and the Cold Water Extraction Process.

In Year 2 (1988/1989) of this project, testing continued with simulated dredge pond de-icing tests carried out at Esso Resources Canada Limited's test basin in Calgary; continuation of laboratory scale extraction tests; transportation, set-up and field testing of the integrated dredging, pipelining and extraction pilot plant at a location on lease #41 near Fort McMurray; and a detailed engineering study and preparation of final cost estimates for a 800 tonne/hour field demonstration facility. The Year 2 costs were $2.0 million of which AOSTRA has funded 50%.

Year 3 (1989/1990), currently under completion, involved continued testing on lease #41, pilot work on the Cold Water Extraction Process froth to evaluate its separability, sedimentation tests on the tailings and the compilation of a Design Basis Memorandum and cost estimate for the semi-commercial dredge and Cold Water Extraction Process field demonstration facility. The Year 3 costs were $4.6 million of which AOSTRA funded 50%.

As a consequence of the encouraging technical results of the work of the previous three years and the preliminary cost estimates of a commercial mined oil sands facility employing the Cold Water Extraction Process concept, which indicated significant reductions in production costs, AOSTRA has agreed in principle to participate with OSLO in a large-scale field demonstration. This demonstration project will require a further four years to construct and operate and will incorporate most of the features of a commercial operation.

7.3 OSLO Borehole Mining And Cold Water Extraction Process

OSLO has been developing the technical features of a borehole hydraulic mining process to mine oil sands hydraulically by means of high pressure water jets operating in sub-surface chambers in an oil sands formation. This technique would be applicable to oil sands reserves located at depths between 300 and 800 feet and would incorporate the synergisms of hydraulic mining with the Cold Water Extraction Process currently being developed in conjunction with oil sands dredging. OSLO leases contain about 17 billion barrels of bitumen in this depth range which cannot be economically extracted by surface mining or in situ methods currently used commercially by industry.

AOSTRA to date has participated in the first two years of a four-year OSLO program together with Energy Mines and Resources Canada (CANMET). Funding for Year 1 by AOSTRA was $247,500, (37.5% of $660,000). The Year 1 Program consisted of jetting tests in air and under water in both laboratory and field experiments, development of a new extendable arm jetting device and evaluation of special drilling tools and techniques. The encouraging laboratory and field jetting tests led to continued technology development in Year 2.

The Year 2 program has been successfully completed. AOSTRA's funding for Year 2 was $440,000 (50%

of $880,000). Highlights of the 1989 program included; the purchase of a specialized mining tool and system, surface jet cutting tests on lease 41, design and fabrication of a one quarter (1/4) scale extendable arm, geotechnical mathematical modelling of a borehole mining operation in a cavity and a preliminary feasibility screening study of a commercial size borehole mining oil sands project.

The results of the work of the previous two years were sufficiently encouraging to justify proceeding with the next phase of testing involving initial trials to create a sub-surface chamber in an oil sands reservoir using the special tools and techniques developed in the preceding work. AOSTRA has agreed in principle to continue its participation in the coming year.

7.4 Solvent Extraction Sand Agglomeration (SESA) Process

The SESA Process involves contacting mined oil sands with carefully controlled small amounts of water and a naphtha solvent in a rotating drum. The naphtha solvent extracts the bitumen while the water facilitates the agglomeration of the fine clay minerals with the sand particles. In a series of solids-liquid separating steps, bitumen diluted with solvent naphtha and a tailings of agglomerated solids wetted with the naphtha solvent are produced. The solvent is recovered from the bitumen by conventional refinery distillation and from the tailings by evaporation. The recovered solvent is recycled to the SESA Process. The dried agglomerates can be transported by trucks or conveyors to the mined out pit for disposal.

The SESA Process has been developed and piloted on a laboratory scale by the National Research Council (NRC).

Terra Energy Ltd. has been granted a license by Canadian Patents and Development Limited (CPDL) to develop and operate a SESA Process demonstration plant. In 1988, AOSTRA and NRC entered into an agreement to participate with Terra in the preparation of engineering designs and cost estimates for a demonstration plant to test the SESA Process for the extraction of bitumen from mined Athabasca oil sands.

Phase I of the project will cost $1.0 million and is being funded on a 50–50 basis by AOSTRA and NRC. This phase consists of the preparation of engineering designs and capital and operating cost estimates for the construction and operation of a 10 tonne per hour demonstration plant and a technical and economic evaluation of the SESA Process compared to the conventional hot water extraction process.

The preliminary process design, material and energy balances and cost estimates for the 10 tonne per hour demonstration plant are complete.

The engineering, cost estimates and economic studies comparing a commercial 30,000 BPCD mining project incorporating the SESA Process with a similar sized plant utilizing the existing hot water extraction process are also complete.

Work is currently in progress on the final stage of Phase I which involves the detail engineering and cost estimate for the construction and operation of a 10 tonne per hour demonstration plant to be located at an appropriate site near Fort McMurray.

Terra are pursuing with industry and other potential investors, the financing of the construction and operation of the proposed demonstration plant.

7.5 Syncrude/Suncor Bitumen Recovery From Tailings Pond Sludge

The percentage of the total bitumen contained in the oil sands feed to the Syncrude Canada Ltd. and Suncor Inc. plants which is discharged with the extraction process tailings is relatively small. However, after many years of operation, tens of millions of barrels of bitumen have accumulated in the sludge layers of the existing ponds.

Acting on an initiative taken by the operators of the two commercial mined oil sands plants, AOSTRA participated with Syncrude and Suncor in a study to evaluate the costs and benefits of various processes for recovering bitumen from hot water process tailings pond sludge. A two phase study was conducted.

Phase I consisted of a study to identify the most promising technologies and to establish physical and chemical characteristics of the recovered bitumen. Phase I costs were $30,000 shared equally by the three participants.

Phase II of the project involved the participation of an engineering contractor to define and estimate the cost of the selected methods to extract bitumen from the tailings sludge. The most attractive option is being considered by Suncor as the basis for a field pilot and test facility.

The basic engineering, capital and operating cost estimates for the pilot have been completed. Participation in the proposed pilot is currently under review by the interested parties.

7.6 Syncrude Disposal Of Tailing Pond Sludge In Mined Overburden Dumps

There are many millions of cubic meters of sludge in the existing tailings ponds of the two commercial mined oil sands plants and additional volumes are generated annually through the use of the hot water extraction process.

Syncrude Canada Ltd., through previous related studies in the field of

overburden dredging, developed a concept by which tailings pond sludge could be mixed with the Clearwater clay shales of the overburden to form stable overburden dumps. Such a technique of dewatering the sludge by absorption into stable overburden dumps would significantly reduce the environmental impact of the tailings ponds.

Syncrude and AOSTRA have completed a two phase program to evaluate the commercial viability of the concept.

The cost of the Phase I program was $990,000 with AOSTRA's share being $450,000. The program established geotechnical criteria under controlled laboratory and field experiments. The successful results obtained in Phase I lead to full scale testing under commercial operating conditions in Phase II. Testing of the sludge disposal scheme involved 170 ton trucks, dozers and support equipment to transport and mix the sludge and overburden.

The results indicate that improved mixing mechanisms are needed in order to fully take advantage of this concept on a commercial basis. Syncrude will be evaluating options to further optimize this scheme.

The total cost of phase II was $900,000 with AOSTRA's share being $400,000.

7.7 OSLO Hot Water Extraction Process

AOSTRA and OSLO have completed a preliminary test program to evaluate the effect of using the Cold Water Extraction Process chemicals plus air injection in place of caustic soda on the performance of the conventional hot water extraction process. It was believed that the elimination of the caustic would improve the settling characteristics of the fine solids in the tailings without adversely affecting bitumen recovery efficiency. The results of this preliminary investigation were very encouraging and suggested that the chemical substitution might be retrofitted to existing hot water extraction processes as a means of eliminating the tailings sludge problem. AOSTRA and OSLO share the cost of this project on a 50/50 basis with each providing $130,000.

8 Upgrading Program

AOSTRA continues to support the development of improved upgrading processes, particularly the demonstration of high conversion hydrogen addition processes. In previous years tests have been completed on VEBA's Combi-Cracking, HRI's High Conversion H-Oil and Gulf's Donor Refined Bitumen (DRB) processes. This year the major tests were completed on the CANMET Hydrocracking and Lummus LC Fining processes.

8.1 CANMET Hydrocracking Tests

In 1989/1990 two demonstration test programs were completed with the CANMET Technology Group: Petro-Canada Inc. and Partec Lavalin, Inc. The first was a major test of high conversion operation on heavy Alberta feedstock in May 1989 in the CANMET Hydrocracking Process demonstration plant in the Petro-Canada refinery in Montreal. AOSTRA provided $350,000 for this test, one half of the incremental cost of providing the feedstock and operating the plant in the test mode.

Test objectives were met successfully. Pitch conversions of over 90% were sustained in smooth stable operation, in commercial sized refinery equipment This test in Montreal on Cold Lake heavy oil and a pilot plant test on Athabasca bitumen by EMR CANMET near Ottawa confirm the design data base and commercial viability of the CANMET Hydrocracking Process.

AOSTRA also participated in a second CANMET Hydrocracking Process test by providing $100,000, one half the project costs, for a process test on heavy oil from the Liaohe field in China. This test was completed in the summer of 1989 in the EMR CANMET pilot plant near Ottawa. The objectives, to demonstrate the process performance and to obtain a design data base, were achieved in spite of the lower reactivity of the China heavy oil compared to typical Alberta heavy feedstocks.

8.2 LC Fining Test Program

Lummus Crest Inc. have developed a method of achieving high conversion operation of the LC Fining Process through the removal of coke precursors from a pitch recycle stream. AOSTRA is funding one half of the total cost (US $2,230,000) of a test program at the Lummus Technical Center in New Jersey to demonstrate the coke precursor removal feature using Alberta heavy oil and bitumen feedstocks.

Previous tests in 1985/86 showed the concept was feasible and high conversion (over 90%) operation of the LC Fining Process could be maintained using coke precursor removal. In 1989/1990 a 44 day pilot plant program was successfully completed using Alberta feedstocks (Cold Lake, Peace River and Athabasca). Hydrotreating tests have also been completed on the LC Fining Process products to determine the conditions required to meet synthetic crude oil specifications. Engineering studies are now underway to utilize the test data for process design of high conversion heavy oil upgraders based on the revised LC Fining Process.

8.3 Coal Heavy Oil Co-Processing

The first phase of a joint government/ industry project on the co-processing of coal and heavy oil was completed in August 1989. Co-processing is a method of upgrading both coal and heavy oil through high temperature reactions with hydrogen. Coal is a lower cost hydrocarbon than oil so the substitution of coal can reduce the unit cost of upgrading.

The study reviewed the relative merits and economics of co-processing compared to heavy oil upgrading and identified issues affecting its commercial development. The participants included three government organizations, (AOSTRA, Alberta Office of Coal Research and Technology and Saskatchewan Energy and Mines) and eight companies (Alberta Power Limited, Amoco Canada Petroleum Company Ltd., Canadian Occidental Petroleum Ltd., Gulf Canada Corporation, Husky Oil Operations Ltd., Mitsui SRC Development Co. Ltd., Shell Canada Limited and TransAlta Utilities Corporation).

The major conclusion of Phase I was that the potential for co-processing was very dependent on oil prices. At the low bitumen and oil product prices now current, the additional costs for processing coal are not justified by the lower feedstock costs. There is a strong future potential for co-processing as oil prices rise relative to coal costs.

A second phase of this project is being initiated. This phase will define and explore the opportunities that could initiate a pioneering co-processing venture in Alberta.

8.4 Regional Upgrader Business Plan

The Alberta Chamber of Resources is sponsoring the development of a Regional Upgrader Business Plan. The objective of the study is to develop a business framework within which a regional upgrader could be funded and constructed. A total of 17 sponsoring organizations are contributing information, manpower and/or cash to carry out the project. The value of these contributions exceeds $880,000.

AOSTRA's contribution has been in the form of information and expertise to the Technical Committee which has the responsibility for providing technical information such as specifications and cost estimates to the Business and Economics Committees.

The Regional Upgrader Business Plan will be completed in June 1990 and is expected to identify how key areas in our present business environment must change in order for a joint effort of government and industry to construct and operate a regional upgrader in Alberta.

8.5 Synthetic Crude Quality Specification

The cost of upgrading and the marketability of synthetic crude are significantly affected by the product quality specifications. To provide a consistent basis for upgrading process evaluations and a guide for upgrading research, AOSTRA funded a $25,000 study by RTM Engineering Ltd. on synthetic crude oil (SCO) quality specifications.

The study considered a variety of environmental issues and competitive pressures relevant to refining and SCO quality needs in the late 1990's. The proposed SCO specification is essentially equivalent to Alberta light, sweet, 38°API crude with no residual oil content, and is therefore appreciably different to current SCO qualities.

8.6 Upgrading Residue Utilization

A series of upgrading residue combustion tests were completed in 1989. These tests demonstrated that typical upgrading residue pitches could be handled as liquid fuels and burned in conventional industrial furnaces.

The high melting points of the residues meant higher feed temperatures were required for atomization. The high levels of impurities such as sulphur, metals and ash means that emission controls would be required for industrial use of upgrading residue fuels.

A second series of tests has been proposed using the Low NOx SOx (LNS) burner technology developed by TransAlta Technologies Inc. This burner has been developed for emission control in coal combustion. The tests proposed by AOSTRA would test the applicability of the technology to upgrading residues such as coke or pitch. Results on this program are expected in 1990/91.

9 Environmental Activities

The advancement of relevant environmental research, as well as the compilation, assessment and dissemination of pertinent technical information are part of the mandate of AOSTRA. Although not customarily identified as being directed solely at environmental issues, many of AOSTRA's projects deal with the development of technologies which offer potential for environmental benefits, if successfully applied commercially. For the most part, environmental benefits derived from technology development programs undertaken previously by AOSTRA have been supplemental to the broader

goals of enhanced economics, resource utilization and removal of technical roadblocks to resource development. However, AOSTRA has recently begun to take a more proactive approach in the Environmental area, by supporting projects which deal specifically with current environmental issues. AOSTRA has and continues to participate in projects which address:

- New processes for the extraction of bitumen from mined oil sands such as thermal retorting and solvent extraction processes, which generate dry or damp tailings and thus eliminate or reduce the need for tailings ponds.
- High conversion bitumen upgrading processes which reduce the production of upgrader residues that are normally disposed of or stockpiled as waste byproducts, and which permit increased sulphur recovery.
- Produced water treatment processes which permit water for steam generation for in situ recovery to be recycled thereby ensuring supplies of boiler feedwater while at the same time reducing the demand for fresh water and the amount of contaminated water that is sent to deep disposal wells.
- The development of the AOSTRA Underground Test Facility to demonstrate the viability of shaft and tunnel access to bitumen reservoirs that are too deep for surface mining and too shallow for conventional in situ techniques involving high pressure steam injection. Surface disturbance is minimized as a consequence of the underground access to the reservoir.
- Research initiatives which address relevant environmental issues, such as tailings waste disposal, oily produced solids cleanup, reducing the toxicity of oil sands products and the reduction of gaseous emissions such as SO_2, CO_2 and NO_x.

While work is continuing in each of these areas, AOSTRA has recently become involved in a number of projects which directly focus on environmental concerns associated with the oil sands and heavy oil industries.

9.1 AOSTRA/Government/ Industry – Sludge Fundamentals Consortium

The private sector companies presently engaged in commercial mined oil sands projects, as well as AOSTRA and many institutional research organizations, have been searching for solutions to the tailings sludge problem independently of each other for many years.

In 1989, a consortium of research organizations, private sector companies and government entities was assembled to pool their respective scientific expertise and research results in an effort to attack the sludge problem in a coordinated research program. In addition to AOSTRA, the members of the Sludge Fundamentals Consortium are the Alberta Department of Energy, the Alberta Research Council, Energy, Mines and Resources, Canada (CANMET), the National Research Council, Suncor, Inc. and Syncrude Canada Ltd.

The research projects initiated by the Consortium will focus on the development of a better understanding of the physical, colloidal, chemical and organic properties of the oil sands sludge which are thought to inhibit settling of suspended solids, and the methods by which these properties may be altered to promote solids settling.

More than $2 million of in-house research costs will be a work-in-kind contribution by member organizations in the first year of this three-year program. In addition AOSTRA, Alberta Energy and CANMET will contribute cash to a total value of $500,000 in year one, AOSTRA's cash contribution being $200,000.

The cash contributions will be used to purchase additional research work from specific member organizations and to contract other research programs and non-member research groups such as universities.

The Technical Committee has identified eight major areas of relevant research including; microbial activity, rheology, electroacoustic/electrophoretic properties, clay-organic interactions, and literature update. Sub-committees have been delegated to each of these activities. To date, the Technical Committee has recommended, for approval by the Management Committee, 13 research proposals, within 10 different areas of research.

9.2 AOSTRA/Canadian Petroleum Association/Sask-Alta Waste Disposal Co-op – "Evaluation Of New Technologies For Cleanup Of Produced Oily Solids"

Also initiated this year was a cooperative effort among AOSTRA, the member companies of the Canadian Petroleum Association (CPA) and the Sask-Alta Waste Disposal Cooperative, to assess the state-of-the-art technologies available for the cleanup of produced oily solids (especially oily produced sand). By being conducted under the auspices of the CPA, the project involves all of the relevant industrial companies, and the opportunity for all to benefit from the results.

Under the direction of a Project Steering Committee an engineering consultant — Monenco Consultants Ltd. — has been responsible for assembling information on candidate processes and for the preparation of comparative technical and cost evaluations.

The objective of the project is not intended to identify a particular technology as being the preferred choice for clean-up of oily produced solids, but rather to identify new technologies, which demonstrate a high degree of potential for clean-up of heavy oil produced solids and for which little information currently exists. Three technologies identified by a Kepner-Tregoe logical decision analysis were selected for more detailed assessment by the consultant and then presented to the Project Steering Committee for final consideration. One or two of these technologies will then be selected by the committee for field testing in Phase III of the project.

A total of $60,000 has been allocated for this Phase I portion of the project. AOSTRA's share is $30,000 with CPA contributing $20,000 and Sask-Alta. Waste Disposal Co-op contributing $10,000.

9.3 AOSTRA – "In House" Environmental Initiatives

Environmental Audit Program:

Environmental audit programs are conducted to identify and assess situations which may not be in accord with regulatory requirements or corporate standards, or which represent undesirable risks to the corporation, community or public. They are constructive management tools, without any intent to reprimand or reward individuals in the corporation.

To date AOSTRA has undertaken environmental audits of five facilities: Amoco GLISP, Norcen Bodo, Husky Kearl Lake, Bow Valley Industries and the Underground Test Facility. Two of these audits are complete (Norcen Bodo and Husky Kearl Lake) with final copies of the reports issued to all parties involved. The remaining three are in final rewrite, with Amoco GLISP serving as the model for a slightly revised format. The revision of format is largely a paring down of the content of the audits, as well as incorporation of suggestions and comments from the parties involved.

Subsequent audits will be conducted according to a more formal and concise framework. The main thrust of this initiative is that the audits be conducted and used as an environmental management tool, and not just an examination of environmental compliance.

A properly conducted auditing program of projects in which AOSTRA is either the operator or a participant will highlight AOSTRA's environmental commitment in the following manner:

- It will ensure compliance as per operating licenses and permits.
- It will ensure compliance as per AOSTRA's guidelines, recommendations and environmental commitment (including best practicable technology).
- It will ensure that the facility will not present problems upon decommissioning or expansion.
- It will serve as an aid to project management in order to meet and hopefully exceed the above goals.

Associations:

AOSTRA continues to actively participate on the Canadian Heavy Oil Association (CHOA) Environmental Committee, as well as a committee recently established by Environment Canada to examine CO_2 emission and reduction strategies.

Recently, AOSTRA became an Associate member of the CPA (Canadian Petroleum Association). Membership in the CPA will allow AOSTRA to become more closely associated with developments in the oil industry and in particular heavy oil and bitumen. The CPA is well recognized for its efforts in the development of environmental criteria within the oil and gas industry. Consequently, participation by AOSTRA on some of these Environmental Committees will provide both a window on and input into the environmental direction of industry.

10 University Programs

10.1 Lectureships

The AOSTRA Lectureship Program was introduced in 1988. The program is intended to fund experts from Canada and abroad to travel to Alberta to present seminars or courses to industry and to the research community in areas relevant to AOSTRA's mandate. It provides a means of teaching new skills needed to make Alberta's oil producing industry more competitive.

In a survey, it was determined that the province needed to develop expertise in the science of colloids and surfaces. Colloids such as the fine dispersions of clay and oil found in produced fluids and in tailings ponds are difficult and expensive to handle. Consequently, in August 1989, Dr. Tharwat Tadros of ICI Agrochemicals, Berkshire, U.K., provided 32 hours of advanced lectures on the chemistry of colloids. These lectures were directed to 40 experts invited from university, industry and government. AOSTRA, CANMET and Syncrude Canada Ltd. co-organized the lectures and provided financial support.

10.2 Graduate Scholarships And Fellowships

Post-graduate scholarships and fellowships have been made available over a 12-year period to graduate and post-doctoral students doing oil sands research at the University of Alberta,

the University of Calgary and the University of Lethbridge. Current award holders are identified in the following lists. The scholarships are for a maximum period of two years and the research done will normally lead to either a Masters or Doctoral degree. Fellowships are intended to assist post-doctoral scientists in furthering their training. Many of these people will eventually do research in industry.

University of Alberta

Bell, D.D.	Maslowski, R.
Bradley, S.	Mattison, B.W.
Chakrabarty, C.	Nachai, M.
* Chalaturnyk, R	* Phadke, S.
Chang, H.	* Sarmah, K.
* Cloutis, E.	Steer, J.G.
Eastwood, J.	Talman, S.
* Foght, J.M.	Tsingas, C.
Giesbrecht, D	* Udey, S.N.
Hickey, C.	Vekred, K.
Khorashek, F.	Yurkiw, F.
Le, L.	Zheng, B.

University of Calgary

Chong, K.	Lewis, J.M.
Eastick, R.	* Maier, R.
Gupta, S.	Nighswander, J.A.
* Lappin-Scott, H.	Mehta, S.A.

* Fellowship

10.3 University Research Program

Program

AOSTRA continues to support a wide range of oil sands and heavy oil related research projects at Canadian universities. The University Research Program covers many areas of practical interest ranging from fundamental research to new process development for the recovery and upgrading of bitumen and heavy oil. Since 1976, nearly 500 graduate students and post-doctoral fellows have developed the needed special skills and obtained advanced degrees in the broad field of oil sands engineering and science. Most are working in Alberta's oil industry. More than 80 professors now consult in this industry and teach and do relevant research at Canadian universities.

The budget in 1989/1990 for support of research in Canadian universities amounted to approximately $2.5 million. Total funds expended in the previous 14 years amounts to $28,698,440.

Universities provide a special environment for doing projects that test "radical" or highly innovative concepts. This is probably a direct result of the emphasis on creativity in universities and the availability of bright graduate students seeking advanced degrees. Brief descriptions of the current projects follow:

1. Dr. A.K. Ambastha of the University of Alberta is determining the applicability of pressure-falloff tests to determine the size of the steam chamber and other parameters that affect the performance of the steaming processes for recovery of bitumen and heavy oil. Data from field tests and from numerical models of fractured wells, horizontal wells, composite reservoirs, etc. will be analyzed. Funds for this three-year project amount to $173,460.

2. Dr. M.C. Baird of Queen's University is developing water-soluble catalysts whose aqueous solutions dispersed finely in bitumen will catalyze the hydrogenation of unsaturated linkages of bitumens at temperatures much lower than those of conventional processes. This project has been funded at $80,000 over two years.

3. Drs. L.A. Behie and W.Y. Svrcek of the University of Calgary are generating basic kinetic data for ultrapyrolysis of Alberta heavy oil using a novel microreactor system and determining product distribution. Funding of this work amounts to $203,000 over three years.

4. Drs. D.W. Bennion and R.G. Moore of the University of Calgary are continuing their investigation of mechanisms of dry and wet in-situ combustion in oil sands and the low temperature oxidation of bitumen. Funding for this project amounts to $325,000. Total funding for this project and ones done over the past thirteen years is $2,293,764.

5. Drs. P.M. Boorman, R.A. Kydd and T.S. Sorensen of the University of Calgary are developing hydrocracking catalysts capable of being used under relatively mild temperature conditions to enhance the yield of liquid products with low aromaticity. Funding of this project amounts to $198,682 over four years. Total funding of this project and previous ones done since 1976 by Dr. Boorman amounts to $698,713.

6. Dr. R.M. Butler of the University of Calgary is doing theoretical- and physical-model studies of the steam-assisted gravity-drainage process for the recovery of heavy oils and bitumen. Funding of this three year project is $330,000. Funding of previous ones amounts to $912,500.

7. Dr. P.M. Byrne of the University of British Columbia is studying deformation and flow of fluids in oil sand masses adjacent to excavations or tunnels. Funding of this one-year project and earlier ones with Dr. Y.P. Vaid amounts to $86,918.

8. Drs. F.S. Chute and F.E. Vermeulen of the University of Alberta have been measuring electrical properties of oil sands, developing physical models of electrical heating processes, and evaluating the use of electrical power for selective heating of oil sands. Funding of this three-year project is

$300,000 and for previous ones since 1978 is $567,633.

9. Dr. D.E. Cormack of the University of Toronto is developing a three-dimensional numerical simulator for application to the steam-assisted horizontal-well gravity-drainage process. Also he is investigating the effects of non-condensable gases on the development of steam chambers. Funding of his current two-year project and earlier studies amounts to $215,310.

10. Dr. J.W. Costerton of the University of Calgary is investigating the use of bacteria to selectively plug high permeability zones in a reservoir and thereby improve conformance of waterfloods and inhibit coning. A total of $797,000 has been allotted to this and earlier projects over eight years.

11. Dr. P.J. Crickmore of the University of Alberta is using fractal analysis as a tool in solving problems in the recovery of bitumen from oil sand. The cost of this project is $77,080 over two years.

12. Dr. F.A.L. Dullien of the University of Waterloo is doing laboratory studies to investigate a novel process using gas to displace residual oil from samples of oil sands core that have been waterflooded. An X-ray CAT scanner is used to determine production history, saturations and relative permeabilities of small elements of these heterogeneous cores. Funds for this three-year project amount to $239,160.

13. Dr. M.B. Dusseault of the University of Waterloo completed a project to measure and model the volume and permeability changes that occur under the low shear-stress conditions that accompany high-pressure injection of steam and other fluids during in situ recovery. He is completing another project to obtain geotechnical data needed to assess novel technological approaches to management of mine wastes deposited as overburden and tailings ponds. He began a new project studying the mechanics of the interactions of small particles of sand or clay and relating such to modeling processes of hydraulic fracturing and sand production. Funding of this project and previous ones since 1977 amounts to $792,477.

14. Dr. N.O. Egiebor of the University of Alberta is doing bench-scale pilot tests to determine the technical and economic feasibility of a novel process for combustion of coke. Coke is co-agglomerated with a specially prepared silica sorbent to make a smokeless solid fuel that provides much reduced emissions of sulphur dioxide. Funds for this one-year project amount to $62,000.

15. Dr. S.M. Farouq Ali of the University of Alberta is studying the use of small amounts of carbon dioxide gas to improve the commonly-used waterflooding process for recovery of Alberta's light oils, developing new methods of control of mobility to improve recovery of heavy oil or bitumen from the Athabasca and Lloydminster deposits and improving a computer program that models oil recovery and fracturing of oil sands formations during injection of steam. Funding of these projects amounts to $1,871,068 over 10 years.

16. Dr. M.R. Gray of the University of Alberta continues to develop methods to characterize heavy oils, bitumens and other feedstocks in terms of functional groups and other chemical moieties and how such affect the kinetics of refining these feedstocks. Funding of this three-year project, and an earlier one with Dr. I.G. Dalla Lana amounts to $479,000.

17. Dr. L.G. Hepler of the University of Alberta is investigating the kinetics and thermodynamics of oxidation of bitumen to obtain quantitative relationships useful in modeling in-situ recovery processes. Funding for this two-year project and earlier ones on colloids, sludge treating and gas dissolution in bitumen has amounted to $1,116,988 over twelve years.

18. Dr. I.E. Hutcheon of the University of Calgary is doing laboratory work and field studies to characterize the dissolution and precipitation of minerals in thermal processes for recovery of bitumen. Funding of this eight-year project amounts to $782,290.

19. Drs. J.B. Hyne and P.D. Clark of the University of Calgary are completing a study of methods to accelerate the chemical reaction of bitumen with steam and hot water that have been injected into an oil sands formation. This reaction, called aquathermolysis, reduces the viscosity of the bitumen. The cost of this project and earlier work by Dr. Hyne is $537,505.

20. Dr. A. Jeje of the University of Calgary is studying fundamental mechanisms that affect the efficiency of the hot-water process used to extract bitumen from mined oil sands. The amount of funding for this two-year project and for an earlier one on in-situ oil recovery by injection of carbon dioxide gas is $118,520.

21. Drs. N.E. Kalogerakis and A.K. Mehrotra of the University of Calgary are measuring and modeling the distribution of carbon dioxide gas between oil and brine as would occur in a recovery process. $309,923 has been allotted to this and earlier projects over an eight-year period.

22. Drs. E. Kanasewich and E. Nyland of the University of Alberta completed development and testing of computer algorithms that interpret signals received by geophones monitoring microseisms produced by an in situ

process. The algorithm determines the distance and direction of the sources of the microseisms relative to the locations of the geophones. Total funding of $949,572 has been allocated for this and earlier work over an eight-year period.

23. Dr. W.G. Laidlaw of the University of Calgary is developing a numerical model based on network theory to characterize the flow of foam through an oil sands formation. Funds for this three-year project amount to $135,000.

24. Drs. S. Levine and B.D. Bowen of the University of British Columbia are using theory and experiment to identify the mechanisms by which fine particles and clays stabilize the emulsions that are found in oil sands tailings ponds. Funds for this seven-year project amount to $432,416.

25. Dr. F.J. Longstaffe is doing a detailed regional study of natural diagenesis in sands, sandstones and shales of the Clearwater Formation near Cold Lake, Alberta. Funds for this two-year project and an earlier related one amount to $123,817.

26. Dr. B.C.-Y Lu of the University of Ottawa is doing laboratory experiments to measure phase equilibria of mixtures of water and bitumen under conditions obtained in in situ recovery processes. Funding for this project and an earlier one amounts to $286,460 over five years.

27. Dr. H. Machel of the University of Alberta is doing petrographic and geochemical studies of carbonate rocks and connate fluids obtained from the Grosmont and Hondo formations to identify and determine the effects of the major diagenetic processes. The cost of this four-year project is $232,000.

28. Dr. J. Masliyah of the University of Alberta is studying methods of cleaning the froth that is obtained by flotation of hot slurries of oil sands and water. Also, he is measuring the rheology of these slurries and those found in tailings ponds. The cost of these three-year and two-year projects amounts to $330,560.

29. Drs. N.R. Morgenstern and J.D. Scott of the University of Alberta are measuring the strength, deformability and permeability of oil sands that are being subjected to the high temperatures and pressures obtained in in-situ steaming processes. One of the geomechanical models developed in this project is being used to predict the safety and performance of tunnels in the Underground Test Facility near Fort McMurray. Funds for this project and previous related ones over a 10-year period amount to $1,064,209.

30. Dr. K. Muehlenbachs of the University of Alberta is measuring the concentrations of isotopes of hydrogen and carbon in current commercial and experimental processes for upgrading of bitumen. The data shows details of effects of certain catalysts on the "scrambling" of hydrogen and carbon moieties that occurs in these processes. Funding for this three-year project amounts to $203,000.

31. Dr. S.G. Pemberton of the University of Alberta is investigating the regional stratigraphy and depositional history of the Grand Rapids Formation in the Athabasca, Wabasca and Cold Lake deposits. Traces of fossil workings and of fossils provide good paleontological control of facies. Studies of data from many thousands of wells provide good regional predictive capability. Funds for these projects and previous related ones are $436,265.

32. Dr. D.Y. Peng of the University of Saskatchewan is developing an equation of state that provides a thermodynamic description of continuous distribution of hydrocarbons found in bitumen/gas mixtures. Funds for this and an earlier project amount to $126,240 over four years.

33. Dr. V.R. Puttagunta of Lakehead University completed work to develop a simple correlation to predict the viscosity of bitumen-gas mixtures over a wide range of pressures and temperatures. This two-year project cost $40,000.

34. Dr. J.A. Rogers of the University of Alberta is developing microencapsulation techniques to transport bacterial nutrients into a reservoir. Microcapsules of diameter less than one micron can be placed at depth in a reservoir to release contents over at least a 30-day period. This one-year project is related to one described earlier for Dr. Costerton and costs $55,000.

35. Drs. J.S. Rogers and F.W. Jones of the University of Alberta are completing studies of short- and long-term tilt of the ground at an oil sands steaming pilot, the AOSTRA/Amoco GLISP site. Data from novel tiltmeters showing tilts of the order of one ten-millionth of a degree are correlated with records of fluid flows. A numerical model is used to simulate the data. The cost of this eight-year project is $382,345.

36. Dr. D.R. Schmitt of the University of Alberta has developed an ultrasonic device that may be lowered in a wellbore to measure deformations of and near the wellbore and to observe fluid breakout. Results of observations taken while nearby wells are being steamed are used to determine in situ horizontal stress directions as a function of time. Funds for this three-year project are $228,684.

37. Drs. J.D. Scott and N. Kerr and Ms. E.A. Richards of the University of Alberta completed designs and fabrication of prototypes of geotextile filters to be used in conventional production of heavy oil. These filters provide low pressure drops and little plugging while

screening sand from oil and water flowing into a well. Funds for this project and an earlier one amount to $129,566 over three years.

38. Dr. T.J.T. Spanos of the University of Alberta is developing fundamental mathematical expressions that describe flow of mixtures of bitumen, water and gas in heavy oil reservoirs. Also, expressions have been developed to describe the propagation of seismic waves through an oil sands deposit. These expressions are now being incorporated into numerical models. The cost of this project and earlier ones amounts to $452,973 over eight years.

39. Dr. O.P. Strausz of the University of Alberta is doing laboratory experiments to assess the use of superacids for commercial hydrocracking of bitumen and heavy oil. Also, he is developing new processes such as continuous steamflow coking for upgrading of bitumen. Funds for these two projects is $400,000 over four and a half years. Funds for previous projects on the chemistry of bitumen, causes of poor recovery of bitumen from some deposits and on soluble catalysts for hydrotreating amount to $3,180,184 over 12 years.

40. Dr. E.L. Tollefson of the University of Calgary is completing bench-pilot scale experiments of a novel process to minimize bogging that can occur in a commercial fluidized-bed coker. Funds for this two-year project are $200,000 . Funds for earlier work on desulphurization of coke and on sludge treatment are $578,370 over eight years.

41. Dr. J.K.S. Wan of Queen's University is completing bench-scale pilot experiments on a novel process that uses microwave heating of dilute catalysts to selectively hydrocrack volatile fractions of bitumen. Also, Dr. Wan is doing similar experiments to improve his patented process for generation of alphaolefins from alkanes. Total funding of this and previous projects is $537,384 over six years.

42. Dr. N.C. Wardlaw of the University of Calgary is doing microscopic studies of sandstones and carbonates obtained from Alberta reservoirs to determine the effect of factors such as wettability and pore geometry on fundamental processes important to enhanced recovery of bitumen and heavy oil. Funds for this project and earlier ones amount to $537,384 over six years.

43. Dr. D.W.S. Westlake of the University of Alberta is completing laboratory studies of the ability of certain microorganisms to metabolize asphaltenes that are a major component of bitumen and heavy oil. Changes in chemical composition of these asphaltenes such as the ratio of aliphatic to aromatic hydrogen, the incorporation or removal of oxygen into molecules and changes of molecular weight of certain fractions are monitored. This two-year project costs $87,500.

Professors periodically report the progress in their research and assign ownership of their technology to AOSTRA. At the Technical Review Meeting and Seminar held each year in October, the professors and their students present the current results of their research. This year 250 senior scientists and engineers from the oil industry, universities and government attended the meeting to learn about the progress on 65 current and completed projects.

The AOSTRA/University/Industry ACCESS Program provides companies with reports of current research, regular interaction with researchers, non-exclusive technology use rights and an opportunity to participate in project evaluation and selection. An Associate Membership category in this program allows companies to obtain membership privileges with somewhat restricted participation in evaluation of projects and technology use rights. In 1989/90, nineteen companies participated in the program as full or associate members at annual fees of $50,000 or $10,000, respectively.

11 AOSTRA – Alberta Research Council Program

AOSTRA continues to support laboratory research on oil sands and heavy oils at the Alberta Research Council (ARC). This research is generally divided into two main groups: "**Core Research**" and "**Strategic Research.**"

11.1 Core Research

The Core Research Program focuses mainly on the regional and generic problems which are common to much of the industry. The program provides an interface between fundamental and applied industrial research, complements expertise in universities and industry, and aids technology transfer and problem solving.

The Core Research projects are currently funded jointly with ARC and in some cases, another government agency, as well as support from industry. Three major programs under the "Core Research" category are as follows:

1. Oil Sands and Hydrocarbon Recovery Research:

This is the fourth year of a five year AOSTRA/ARC/Industry Joint Research Program. 1989/90 fiscal year expenditures were $3.0 million with industry providing approximately $0.7 M, with the balance being split 50/50 between AOSTRA and ARC. With active participation by industry, five

multi-disciplinary projects were designed to address an identified technical need, with both short and longer-term objectives and schedules:

- To provide a quantitative description of the fundamental mechanisms that control fluid flow in elements of the reservoir;
- To develop procedures and processes for controlling flow patterns in homogeneous and heterogeneous reservoirs.
- To develop advanced, steam-based recovery processes which would have application in field pilot trials.
- To provide a quantitative description of the geochemical processes occurring in near-well regions of the reservoir and to develop new remedial procedures that can counteract deleterious effect.
- To develop correlations and models for calculating the properties of reservoir fluids under in situ conditions.

The Program involves a total of approximately 27 man-years of professional and technical efforts and is closely coordinated. Notable achievements in the 1989/90 fiscal year include:

- The first three-dimensional saturation for a steam-drag process has been obtained by high temperature X-ray computed tomography experiments. Successful simulation of the steam-drag data has a significant impact on predicted rates of bitumen production.
- Regimes which favor the formation and propagation of dispersions such as foams and emulsions were identified for applications to improve reservoir performance.
- An investigation into the recovery of bitumen from a Cold Lake reservoir with a bottom water zone showed that flue gas additives in steam accelerate hot communication and improve early recovery.
- A three-dimensional steam-air run and subsequent mechanistic study showed that air is an effective diversion agent under a certain temperature range and air concentration in the injection fluid.
- A novel method to measure dynamic wettability of dispersed reservoir sand was proposed and tested successfully, and is the subject of a patent disclosure.
- A visual cell was developed to determine phase relationships in multi-component and multi-phase systems which may include water. The apparatus was used to measure the solubility of methane in Cold Lake bitumen in the presence of water.

The transfer of technology from this program is via the AOSTRA/ARC/ Industry Access Program through which participating companies are involved in all stages of project definition, direction and management. The Access Member companies are provided with direct access to research results, commercial use rights of project technology, and the opportunity to play a major role in developing the research program.

Long range planning for the Program will be the responsibility of the newly created Policy and Program Committee which held its inaugural meeting in September 1989. The Chief Executive Officers of both AOSTRA and ARC serve on this Committee, along with senior executives from Access Member companies.

The technical progress of the Program is monitored by a Technical Committee, that is composed of Access Member representatives and the AOSTRA and ARC program managers. Interaction at the working level is provided by project sub-committees, which include research or engineering staff from each Access Member, AOSTRA and ARC.

During the year the membership grew from nine to eleven, with the decision by Amoco Canada Petroleum Company Ltd. and the China National Petroleum Corporation to join the program.

2. Regional Geology Studies:

This Program is supported on an equal tripartite basis by AOSTRA, ARC and the Alberta Department of Energy. Each agency contributes $400,000 per year to capitalize upon the existing geological expertise and database in oil sands. The research program focuses on regional geological characterization of the unmapped portions of the oil sands deposits and on parameter estimation for detailed reservoir modelling.

The resource characterization studies provide fundamental insight into the stratigraphic and structure setting of the oil sands deposits, define the sedimentologic and mineralogic framework of the reservoir horizons, and document fluid distribution and saturation. Acquisition of this information yields baseline data against which decisions on resource assessment, development and recovery strategies can be addressed. Complementary to these more regional investigations, the detailed geological reservoir modelling studies are focussed on the finer scale attributes of oil sand and heavy oil reservoir fabric. It is intended to provide more sophisticated insight into the identification, scaling and quantitative modelling of geological and petrophysical parameters.

The technical information generated from the Program is also made available to the industry through the Access Program.

3. Hydrocarbon Processing and Upgrading Program:

This is the third year of a five-year arrangement between AOSTRA and ARC on a 50/50 basis. In the 1989/90 fiscal year, approximately $800,000 was expended. During the year, the major activities in the Program were concentrated in the following areas:

- Evaluation of a new high conversion hydrocracking process;
- Investigation of the coke formation mechanism in upgrading processes;
- Development of novel catalysts for bitumen hydrotreating; and
- Construction, commissioning and calibration of a two-liter equilibrium cell for vapor-liquid equilibrium measurements.

In the high conversion project, the pilot plant has been significantly modified by commissioning a new larger reactor. Significant progress was achieved in understanding process chemistry and hydrodynamic behavior of process fluids in the reactor. A patent was filed in May 1989.

The mechanism of converting liquid hydrocarbons to solid coke under thermal process conditions was further investigated. The understanding of the mechanisms of coke formation will eventually lead to improvements in the reduction of coke formation in commercially operated coking processes.

Experimental results show that asphaltene conversion is affected by the pore volume distribution of the catalyst. The specially engineered catalysts have been prepared using various preparation techniques, resulting in structures with a range of pore volume distributions.

11.2 Strategic Research

The Strategic Research Program is designed to provide a confidential forum for applied proprietary research and development to meet AOSTRA's specific needs in all areas of operation. The Strategic Research Program has three broad objectives:

- To apply concepts, results and insights gained from laboratory research to field situations.
- To address specific problems from field operations.
- To investigate and evaluate AOSTRA technology for potential broader application to resource development.

The Program is funded 100% by AOSTRA; approximately $1.5 million was expended in the 1989/90 fiscal year. The Program Committee, which consists of representatives from three different directorates of AOSTRA and one representative from ARC, is continually monitoring progress of the Program to conform with AOSTRA's priorities. A new element in the area of Environmental Research has been added to the Program which now consists of four major fields:

- In Situ Reservoir Related Research
- In Situ Production Related Research
- Surface Extraction and Upgrading Research
- Environmental Research

Much progress has been achieved in 1989/90 and a patent application for a new design of a pump bellows was made during the year.

11.3 Sample Bank

In addition to the research and development programs, such as the "Core Research Program" and the "Strategic Research Program," AOSTRA also continues to support a service project at ARC, the Sample Bank, with approximately two person-years effort. Approximately $123,000 was expended in 1989/90. The prime purpose of the Sample Bank is to support research and Development of all phases of oil sands and heavy oil technology by providing "standard" oil sands, bitumen and other related samples to research workers around the world. During the year, the Sample Bank distributed a total of 40 tonnes of bitumen, oil sands, heavy oil, and related materials in 60 shipments. The value of these shipments was $36,300.

12 Programs At Other Research Organizations

12.1 Computer Modelling Group

AOSTRA and the Computer Modelling Group (CMG) entered into a five-year program of Reservoir Simulation Research beginning April 1, 1986. Initially, two advanced thermal simultors, Thermal Wellbore Simulator (THEWS) and Steam Additive Reservoir Simulator (STARS), were developed. These two simulators were further validated and enhanced. In the past year, THEWS has successfully coupled to STARS and is being tested on a horizontal well case. This advanced wellbore simulator has been named "HOWSIM." CMG also provides support to AOSTRA staff with training, installation and consulting services regarding the use of various CMG developed simulators.

In 1989/90, AOSTRA supported CMG to the extent of $220,000, which is equivalent to two person-years of effort.

12.2 Petroleum Recovery Institute

AOSTRA provided continued support to the Petroleum Recovery Institute (PRI) during the fiscal year 1989/90 by matching Industry contribution to a maximum of $1,000,000.

PRI is currently conducting research in

four major areas related to enhanced oil recovery. The research areas are gas flooding (miscible displacement), sweep efficiency improvement, heavy oil recovery and chemical flooding. The results of this work are available to Industry as well as AOSTRA for potential field applications. PRI also provides technical expertise to AOSTRA for the analyses of the performance of AOSTRA projects, and for special laboratory studies such as microbial enhanced oil recovery tests and aquathermolysis tests.

In 1989, AOSTRA participated in a multi-client study being jointly conducted by PRI and British Columbia Research Council to investigate the use of pulp and paper byproducts as a co-surfactant additive to enhance alkaline flooding and as a resin for sand consolidation. In addition, AOSTRA is participating in a multi-client study being conducted by PRI to investigate the occurrence and significance of fines and pyrobitumen in selected Alberta carbonate reservoirs.

AOSTRA has an agreement with PRI to patent and act as exclusive license agent for technology developed at the Institute. AOSTRA is the owner of the technology.

12.3 Saskatchewan Research Council Multi-Client Research Program

During the fiscal year 1989/90, AOSTRA continued to participate in a number of multi-client research programs being conducted by the Saskatchewan Research Council. AOSTRA receives the results of research being conducted in sand control, emulsions, in situ combustion behavior, thermal studies, miscible displacement, horizontal well technology, and upgrading characteristics of enhanced oil recovery feed stocks.

13 International Programs

Introduction

AOSTRA continued an active international program during 1989/90 with various Memoranda of Understanding being signed with several countries plus active involvement by AOSTRA staff in a number of international activities. AOSTRA continues to work closely with Alberta Economic Development and Trade and with Industry, Science and Technology Canada in promoting Alberta goods and services around the world. This is achieved primarily through AOSTRA's contacts, credibility and acceptance as developed through its activities and also by active participation in trade shows, seminars and trade delegations. AOSTRA also continues to promote the sale of its own technology and is having major success in developing sales for the AOSTRA Taciuk Process (ATP) technology as well as laying the groundwork for sales of several in-situ technologies.

UNITAR

AOSTRA continues, along with Petróleos de Venezuela, Petro-Canada Inc. and the U.S. Department of Energy, to actively support the UNITAR/UNDP Information Centre for Heavy Crude and Tar Sands. In addition to a contribution of $25,000 U.S. per year, AOSTRA pays one-half the cost of maintaining the director and participates actively in the executive board.

Under its new director, the Centre continues to revitalize itself and redirect its activities towards a more viable information exchange Centre with active involvement from other UN agencies and departments and a greater emphasis on transfer of technology from the developed to developing countries.

AOSTRA continues to cooperate with the Centre in planning for the 5th UNITAR/UNDP Conference on Heavy Crude and Tar Sands to be held in Caracas in February 1991 and serves on the Technical Committee for this meeting.

China

Contacts between AOSTRA and CNPC as well as other heavy oil organizations in China have continued in 89/90 but at a lower key than in previous years. China continues to be an active member of the University and ARC Access Programs and AOSTRA participated in the first China National Petroleum Show and has pursued the sale of ATP technology for shale oil recovery and waste clean up in China.

India/Pakistan

AOSTRA initialled a Memorandum of Understanding with India in June 1989 and followed up with technical visits and lectures. Cooperation with the India Reservoir Institute was initiated and a potential sale of ATP technology for refinery waste clean up identified.

Soviet Union

Two specialists from AOSTRA made an extensive visit to the Soviet Union from August to October inclusive in 1989. These delegates were given full access to information on Soviet heavy oil and tar sand reserves and recovery projects and travelled extensively in the Soviet Union. They have identified a number of opportunities for the application of AOSTRA and Alberta technology in the Soviet Union, and in particular, the application of the ATP technology in Kazakhstan and Azerbaijan.

A return delegation of three Soviets consisting of the head of experimental projects in the Soviet Union, director of

heavy oil research and a scientist/ interpreter are currently visiting AOSTRA for a three month period. This group, in addition to studying AOSTRA technology, has been meeting with Alberta companies regarding investment in enhanced recovery in the Soviet Union.

Hungary

During the year, AOSTRA negotiated and signed a new Memorandum of Understanding with the Hungarian Hydrocarbon Institute. Under the terms of this Memorandum one specialist on in situ combustion is in Alberta for several months to work on combustion tube experiments at the University of Calgary using Hungarian technology for burning in light oil reservoirs.

Negotiations are also being conducted on exchanges in field experience in miscible and immiscible recovery and in the area of high temperature gels.

Romania

AOSTRA participated in the Romanian Trade Fair in October 1989 as well as meetings of the Canada-Romanian Business Council. During the visit AOSTRA further explored the use of Romanian greaseless compressors in Canada and the introduction of slant hole drilling technology to Romania.

Yugoslavia

In October, AOSTRA representatives visited the Serbian part of Yugoslavia and in addition to visiting facilities and discussing potential joint projects an Memorandum of Cooperation was signed.

Czechoslovakia

AOSTRA continued to exchange correspondence with Czechoslovakia on the potential for application of Alberta technology for the production of heavy oil with both a gas cap and bottom water. A Canadian expert will travel to Czechoslovakia in July 1990 to consult in this area.

Turkey

A specialist form Turkey visited AOSTRA for two weeks during the first quarter of 1990. Turkey is particularly interested in technology for exploitation of its deep heavy fractured carbonate deposits. The use of horizontal wells and Underground Test Facility technology were explored.

Norway

AOSTRA signed a Memorandum of Understanding with IKU Norway in October 1989. Activities to date have included visits of specialists from IKU to Alberta in October 1989 and April 1990.

UK

The UK has recently established the Petroleum Science and Technology Institute in Edinburgh. It is understood that this Institute will operate on a basis similar to AOSTRA. AOSTRA is conducting discussions with this group on opportunities for further cooperation.

Cuba

A delegation from the Ministry of Basic Industries in Cuba visited Alberta in June 1989. As a result of this visit, and from core samples obtained, AOSTRA agreed to further evaluate the Marga deposit for exploitation using AOSTRA technology. AOSTRA also agreed to provide assistance in developing advanced technology for exploitation of their deep fractured heavy oil deposits.

Trinidad

AOSTRA continues to work with Trinidad on the potential of using AOSTRA and Alberta technology for the production of bitumen from their surface oil sand deposits.

Ecuador

Ecuador has large bitumen/heavy oil deposits which are unexploited and largely undefined and characterized. AOSTRA continues to work with Economic Development and Industry, Science and Technology Canada (ISTC) in the introduction of Alberta technology, goods and services in Ecuador.

USA

AOSTRA continues to play an active role in the Canada-USA Memorandum of Understanding. In addition to participating in semi-annual meetings of the Steering Committee, AOSTRA has been active in formulating new research areas for cooperative research. A new annex to the agreement has been recently signed in the area of operating and control of in-situ combustion with steam and oxygen. In addition, AOSTRA and DOE have exchanged memberships in Stanford University Petroleum Research Institute (SUPRI) and the AOSTRA University Access Program and are cooperating in financing a final report on the seismic research project. Interest has also been shown in a joint project on horizontal drilling, environmental research and biological recovery. In recent meetings, the potential for the use of the ATP technology in shale oil recovery and diatomite processing has been explored.

14 Training Programs

AOSTRA continues to provide training opportunities for young Albertans to obtain experience in hydrocarbon recovery and processing. Four main programs were conducted:

NAIT/SAIT Program

This Program employed 20 NAIT/SAIT students for a four-month period during the summer between their first and second academic year of training. Students were employed on a variety of AOSTRA projects.

Co-op Program

This Program employs engineering students who are on the industrial portion of their co-op training program. Students are employed at AOSTRA's Calgary Office for periods of four or eight months with up to six students at any one time being employed.

New Graduate Assistance Program

This Program gives new university graduates in engineering and geology an opportunity to work for two years and obtain work experience required for professional registration. Six recent graduates are employed at AOSTRA's Calgary and Edmonton offices on this program.

University Summer Student Program

This Program takes top quality students who have completed second or third year university training and employs them with university professors who are working on AOSTRA projects thus giving them the opportunity to become familiar with the potential of doing graduate work in hydrocarbon recovery and processing. AOSTRA employed 21 students in this program.

15 Industrial Post-Doctoral Fellowship Program

In 1983, AOSTRA initiated its Industrial Post-Doctoral Fellowship Program which was designed to assist the transition of post-doctoral researchers from an academic to an industrial environment. During the two-year term of the award, valued at $22,500 per year, the AOSTRA Industrial Fellow conducts a research project in the laboratory of the sponsoring company which provides the space, equipment and support personnel required for the proper conduct of the research.

Currently there are three holders of the award:

- Dr. Keng Haut Chung is studying the use of membranes for the clarification of recycle water from oil sands mining operations. This work is being conducted at the Syncrude Canada Ltd. Research Laboratory in Edmonton, Alberta.
- Dr. Khoon-Sin Tan is responsible for evaluation of Nuclear Magnetic Resonance (NMR) technology for use by Syncrude through the design and completion of a variety of experiments and to act as a technical interface with external laboratories carrying out contract NMR work.
- Dr. Laurie J. Danielson is working on the fundamental aspects of the sludge disposal problem at Syncrude with the aid of Scanning Electron Microscopy, X-Ray Diffraction and NMR Spectroscopy.

16 Inventors Grant Assistance Program

The Inventors Grant Assistance Program (IGAP), first implemented in 1983, was continued during fiscal 1989. The purpose of IGAP is to encourage and assist inventors to develop inventions beyond the idea and concept stage so that conventional funding for commercialization may be obtained. Amounts to a maximum of $50,000 may be awarded to individuals or companies for use in developing inventions. AOSTRA does not earn any use rights to the inventions and the only requirement on the part of the inventor is a commitment to use the funds in the development of the invention and to supply both accounting and technical reports to AOSTRA.

This continues to be a popular program with a total of 21 applications being reviewed during the year. Seven of these applications were approved for funding as follows:

IGAP Recipient	Amount of Grant	Activity Supported
Cantrol Systems	$40,000	Development of a Wireline Hydraulic Retrieving Tool
Hydro-Seal International	$50,000	Ball Valve
E.L. Tollefson	$12,270	Catalytic Oxidation at Low Concentrations of Hydrogen Sulfide
D.A. Jensen & K.R. McConnell	$32,000	DK Valve and Guide Assembly
354744 Alberta Ltd.	$10,000	Hazardous Materials Containment System
D. Utley	$20,000	Installation and Operation of Velocity Increaser System
D. Moore/M. Wawrzynowski	$20,000	Downhole Adjustable Bent Housing for Directional Drilling

Grants awarded under IGAP have totalled $1,286,785 since the program was implemented.

17 Economic Analyses

AOSTRA continues to use economic evaluations to assist in determining the direction of research required to develop new and improved technology. Proposed and active research projects are evaluated to determine their econmic potential. Completed projects are evaluated to establish the potential value of the technology developed and available for sale or licensing. Economic studies provided by applicants, project participants, and studies developed within AOSTRA are utilized.

The economic model for evaluating the commercial potential of new and existing in situ production projects has been developed. The model, available for use on a microcomputer, includes a cost data base which is updated as appropriate. AOSTRA has used the model to evaluate the commercial potential of pilot project expansions.

The economic potential of the production techniques being developed in the Underground Test Facility have been evaluated in a comparison with other available in situ production methods.

Comparative economic evaluations have been made of a number of processes available for commercial processing of bitumen and heavy oils. These evaluations have indicated potential improvements through integration of primary and secondary processing steps.

Preliminary economic evaluations of a high conversion process being developed by the Alberta Research Council are underway. Results from the evaluation will assist in directing future research and development.

The Alberta Chamber of Resources, along with a number of industry and government participants, are developing a study to determine the appropriate business and economic environment required to promote the development of a regional upgrader. AOSTRA has participated in the development of the economic evaluations associated with this study.

18 Publications Department

In an effort to keep technical information on petroleum resources up-to-date and available to scientists and engineers, AOSTRA continued to publish extensively during the year.

One of the major projects undertaken was the publication of the proceedings of the Fourth UNITAR/UNDP International Conference on Heavy Crude and Tar Sands. A five-volume set of hardcover books, which has been described as an encyclopedia of heavy oil and tar sands technology, was produced. Copies of these proceedings may be ordered through the AOSTRA Library and Information Services (ALIS) at a price of $200 for the complete set, or $30 for volume 1 and $60 each for volumes 2 to 5. The proceedings of previous UNITAR/UNDP conferences are also available from ALIS.

AOSTRA continued to expand its Technical Publication Series with number six of the series being published this year. *The AOSTRA Technical Handbook on Oil Sands, Bitumens and Heavy Oils*, edited by Loren G. Hepler and Chu Hsi, can be ordered through ALIS at a price of $50. The five previous publications in the AOSTRA Technical Publications Series are

1. *Syncrude Analytical Methods for Oil Sand and Bitumen Processing;*
2. *The Thermodynamic and Transport Properties of Bitumens and Heavy Oils;*
3. *Aquathermolysis: A Synopsis of Work on the Chemical Reaction Between Water (Steam) and Heavy Oil Sands During Simulated Steam Stimulation;*
4. *Oil Sands Composition and Behaviour Research;*
5. *A Review of Analytical Methods for Bitumens and Heavy Oils*

The AOSTRA 15 Year Portfolio of Achievement was published this year. Celebrating 15 years of achievement, this handsome volume tells the story of AOSTRA from its inception in 1974 to the present. It can by purchased for $15.

The AOSTRA Journal of Research, which is published quarterly, continues to get technical information out to scientists and engineers involved in oil sands and heavy oil research. The TARpaper, also published quarterly, continues to highlight AOSTRA events and people at the leading edge of tar sands and heavy oil research, as well as related activities in the province. Its readership has increased to near 4000 subscribers. Subscription to both of these periodicals can be obtained through ALIS.

Several booklets and pamphlets were also published during the year. The discussion paper, "The Greenhouse Effect and the Alberta Fossil Fuels Industry," by E.J. Wiggins and W.J. Yurko, was published in July 1989 and is available from ALIS at no charge.

Based on the good cooperative relations previously established and aiming at continuing to develop and diversify the economic and technical-scientific cooperation in the field of oil recovery, AOSTRA published two books from Romania. The first was a booklet put out by ROMPETROL-GEOMIN, a

Romanian company for economic cooperation in the fields of oil, gas and mining. Copies of this booklet were distributed to operating oil companies in Canada and a large number of copies were sent to the Romanian Consul General in Montreal for further distribution. The second item published was the book entitled, *Advances in Polymer Chemistry and Technology*.

Work on a book from Russia began in 1989. *Bitumen Deposits of Kazakhstan: Problems and Prospects*, by N.K. Nadirov et al., was translated into English and editing and typesetting are proceeding. It is expected that this book will be completed in 1990.

19 Conferences And Workshops

The AOSTRA Oil Sands 2000 Conference was held in Edmonton in March 1990.

This was an extremely successful conference highlighting the 15 years of achievement by AOSTRA. The conference included an excellent technical program, outstanding displays, and numerous related functions. It was attended by over 400 delegates with several participants from other countries.

The Honourable Donald R. Getty, Premier of Alberta, addressed the AOSTRA Oil Sands 2000 Conference and presented Dr. Barry Mellon the 1990 Karl A. Clark Distinguished Service Award.

In October 1989, the annual meeting of the participants in the University Access Program was held in Banff, Alberta. This meeting gives researchers and company representatives an opportunity to discuss work being carried out at the Universities and to have an input in future directions.

20 Awards

The Karl A. Clark Distinguished Service Award is presented to individuals who have made important contributions to the overall realization of the commercial potential of Alberta's oil sand resources. Currently the Award is made by an external panel of five distinguished Canadians who review the nominations received in an open competition.

In 1989, the Award was presented to Dr. Clement W. Bowman. Dr. Bowman's Award consisted of a distinctive sculpture created specifically for this Award by an Alberta artist and the establishment of a $10,000 scholarship fund at the University of Alberta Chemical Engineering Department in Dr. Bowman's name.

Dr. Bowman worked in oil sands research from 1960 to 1984 starting as a research engineer operating a hot-water extraction pilot near Fort McMurray and continuing his distinguished career in oil sands research to become in 1963 the Research Manager of Syncrude Canada Ltd., in 1969 the Chemical and Petroleum Research Manager of Imperial Oil Enterprises; in 1975 the Chairman and Chief Executive Officer of AOSTRA, and in 1984 the Vice-President of Research of Esso Petroleum Canada. Since 1986, Dr. Bowman has been the President of the Alberta Research Council. His significant inventions are described in 13 Canadian and U.S. patents on oil sands research.

This prestigious Award had been made twice on previous occasions. The first was made in 1969 to Mr. S.C. Ells, a scientist with the federal government who did much of the original geological investigation of the oil sands and who also did considerable work on the water-extraction process. The second was made in 1982 to Dr. Paul Gishler who was an important driving force in the development of AOSTRA and who became one of the first Members of AOSTRA. Dr. Gishler was a scientist with the National Research Council where he invented the spouting-bed technology, a technology developed from his pioneering studies of fluidized-bed pyrolysis of tar sands.

Chairs

In January 1990, Dr. William Costerton of the Department of Microbiology of the University of Calgary, was awarded the NSERC Chair of Bacterial Biofilm Research. This important award was made in recognition of his internationally recognized contributions to the study of fouling of surfaces by bacteria. Of the 81 NSERC Chairs granted, three including this one are held in Alberta. It was felt that the combined support of industry and AOSTRA was important in gaining this one.

The term of the Chair is five years and annual support amounting to $604,600 is provided, 50% by a consortium of 18 companies, including AOSTRA, and a matching 50% by the National Science and Engineering Research Council (NSERC). AOSTRA's support for the Chair amounts to $40,000 per year.

In previous years, Dr. Costerton held an AOSTRA Professorship Award of approximately $500,000 and received research contracts amounting to $797,000 over an eight year period. Dr. Costerton holds many significant inventions including a patented process for selectively plugging a subterranean formation. This process is owned by AOSTRA and results of pilot-scale tests are encouraging.

21 AOSTRA Library And Information Services (ALIS)

AOSTRA Library and Information Services' multi-disciplinary team of technical information officers and support staff in both Edmonton and Calgary, provides fast, accurate information on oil sands, heavy oil and enhanced recovery processes. Hard copies of all material are available at both sites.

AOSTRA's confidential information is also computerized and the hard copy filing system is in place. This information consists of:

- AOSTRA/Industry Field Pilot Projects;
- AOSTRA/University Research Program Agreements;
- AOSTRA/Industry Mining, Upgrading, Extraction Projects;
- AOSTRA/ARC/Industry Program in Advanced Thermal Recovery;
- AOSTRA/ARC Strategic Program;
- AOSTRA/ARC Upgrading Study;
- AOSTRA/ARC Geology Program;
- IGAP (Inventors Grant Assistance Program);
- AOSTRA Patents.

In addition, ALIS distributes the TARpaper, the AOSTRA Journal of Research and all other AOSTRA publications.

22 AOSTRA Patents

The following patents and patent applications are assigned to AOSTRA:

A) Canadian Patents

Patent No.	Date Issued	Patent Title
1,102,234	Jun 2/81	Gaseous and Solvent Additives for Steam Injection for Thermal Recovery of Bitumen from Tar Sands (D.A. Redford and M.R. Hanna)
1,120,418	Mar 23/82	Process and Apparatus for Thermally Proccessing Heavy Hydrocarbon-Containing Liquids (W. Taciuk)
1,121,749	Apr 3/82	Apparatus and Process for Recovery of Hydrocarbons from Inorganic Host Materials (W. Taciuk)
1,122,015	Apr 20/82	Process for Microbiologically Leaching Coke (T.R. Jack et al)
1,134,174	Oct 26/82	Two-Phase Wet Steam Flowmeter (1) (D.S. Scott and E. Rhodes)
1,158.458	Dec 13/83	Variable Drive for Pump Jack (D.L. Buckler)
1,170,444	Jul 10/84	Use of Hydrogen-Free Carbon Monoxide with Steam in Recovery of Heavy Oil at Low Temperatures (J.B. Hyne and J.D. Tyrer)
1,171,382	Jul 24/84	Electrophoretic Process for Separating Aqueous Mineral Suspensions (R.A. Ritter)
1,189,444	Jun 25/85	Additive for Inclusion in a Heavy Oil Reservoir Undergoing Steam Injection (J.B. Hyne and P.D. Clarke)
1,206,465	Jun 24/86	Catalytic Sulfur Removal from Hydrocarbons (P.M. Boorman et al)
1,210,358	Aug 26/86	Process for Upgrading a Heavy Viscous Hydrocarbon (I.H. Lutz) (Acres Davy McKee D.M. International, Inc., Houston, Texas)
1,220,646	Apr 21/87	Two-Phase Flowmeter (2) (D.S. Scott and E. Rhodes)
1,225,129	Aug 4/87	Commutator (R.A. Ritter)
1,235,652	Apr 26/88	Method for Obtaining Horizontal Fractures in an Oil Reservoir (T. Harding et al)
1,239,088	July 12/88	Method for Controlling Water Coning in Oil Wells (R.W. Luhning and K.R. Ronaghan)
1,241,293	Aug 30/88	Microwave Induced Catalytic Conversion of Methane to Ethylene and Hydrogen (J. Wan)
1,248,069	Jan 3/89	Apparatus for Continuously Separating Particulate Solids from Liquid Suspensions (R.A. Ritter)
1,184,022	Mar 19/85	Use of Surfactants to Improve Oil Recovery During Steam Flooding (E.E. Isaacs and D.R. Prowse)

B) **Canadian Patent Applications**

Application No.	Date Filed	Patent Application Title
369,403-8	Jan 27/87	Wet Combustion Process (D.W. Bennion et al)
379,072	Feb 22/83	Improved Process for Recovery of Residual Bitumen from Tailings from Oil Sand Extraction Plants (E.L. Tollefson and E. S. Hall)
517,837	Sep 9/86	Pressure-Up/Blowdown Combustion — A Channelled Reservoir Recovery Process (R.J. Hallam and J.K. Donnelly)
552,801	Nov 19/87	Microbial Process for Selectively Plugging a Subterranean Formation (J.W.F. Costerton)
552,920	Nov 26/87	Steam Drive/Oil Recovery Process Involving Horizontal Boreholes (P. Toma)
574,694	Dec 20/88	Method and Apparatus for Measuring Fluid Viscosity (B.B. Maini)

C) **U.S. Patents**

Patent No.	Date Issued	Patent Title
4,180,455	Dec 25/79	Process for Thermally Cracking a Heavy Hydrocarbon (W. Taciuk)
4,271,905	Jun 9/81	Gaseous and Solvent Additives for Steam Injection for Thermal Recovery of Bitumen from Tar Sands (D.A. Redford and M.R. Hanna)
4,280,879	Jul 28/81	Apparatus and Process for Recovery of Hydrocarbons from Inorganic Host Materials (W. Taciuk)
4,285,773	Aug 25/81	Apparatus and Process for Recovery of Hydrocarbons from Inorganic Host Materials (W. Taciuk — Lloydminster Version)
4,306,961	Dec 22/81	Process for Recovery of Hydrocarbons from Inorganic Host Materials (W. Taciuk — Tarsand Version)
4,312,234	Jan 26/82	Two-Phase Wet Steam Flow Meter (1) (D.S. Scott and E. Rhodes)
4,438,218	Mar 20/84	Catalytic Sulfur Removal from Hydrocarbons (P.M. Boorman et al)
4,454,023	Jul/Aug/84	Process for Upgrading a Heavy Viscous Oil (Hydrocarbon) (I. Lutz) (Acres Davy McKee DM International, INc., Houston)
4,458,759	Jul 10/84	Use of Surfactants to Improve Oil Recovery During Steam Flooding (E.E. Isaacs and D.R. Prowse)
4,487,264	Dec 11/84	Use of Hydrogen-Free Carbon Monoxide with Steam in Recovery of Heavy Oil at Low Temperatures (J.B. Hyne and J.D. Tyrer)
4,501,648	Feb 26/85	Electrophoretic Process for Separating Aqueous Mineral Suspensions (R.A. Ritter)
4,506,733	Mar 26/85	Additive for Inclusion in a Heavy Oil Reservoir Undergoing Steam Injection (J.B. Hyne and P.D. Clarke)
4,574,038	Mar 4/86	Microwave Induced Catalytic Conversion of Methane to Ethylene and Hydrogen (J. Wan)
4,574,643	Mar 11/86	Two-Phase Wet Steam Flowmeter (2) (D.S. Scott and E. Rhodes)
4,623,203	Nov 18/86	Commutator (R.A. Ritter)
4,623,442	Nov 18/86	Apparatus for Continuously Separating Particulate Solids from Suspensions (R.A. Ritter)
4,718,489	Jan 12/88	Pressure-up/Blowdown Combustion — A Channelled Reservoir Recovery Process (R.J. Hallam and J.K. Donnelly)
4,800,959	Jan 31/89	Microbial Process for Selectively Plugging a Subterranean Formation (J.W.F. Costerton)
4,890,482	Jan 2/90	Method and Apparatus for Measuring Fluid Viscosity (B.B. Maini)

D) **U.S. Patent Applications**

Application No.	Date Filed	Patent Application Title
06/294.523	Aug 20/81	Variable Speed Pump Jack (D.L. Buckler)
229,349	Jan 29/81	Wet Combustion Process (D.W. Bennion et al)
784,933	Oct 7/85	Method for Controlling Water Coning in Oil Wells (R.W. Luhning and K.R. Ronaghan)
834,177	Feb 2/86	Method for Obtaining Horizontal Fractures in an Oil Reservoir (T. Harding et al)
132,803	Dec 14/87	Steam Drive/Oil Recovery Process Involving Horizontal Boreholes (P. Toma)
229,008	Aug 5/88	Recovery of Bitumen or Heavy Oi In Situ by Injection of Hot Water or Low Quality Steam Plus Caustic and Carbon Dioxide (A.S. McKay)

E) **Venezuela Patents**

Patent No.	Date Issued	Patent Title
3729	Jun 10/80	Process for Microbiologically Leaching Coke (J. Zajic et al)
785/81	May 9/81	Two Phase Wet Steam Flow Meter (D.S. Scott and E. Rhodes)
1299/82	Jul 21/82	Use of Hydrogen-Free Carbon Monoxide with Steam in Recovery of Heavy Oil at Low Temperatures (J.B. Hyne and J.D. Tyrer)
3714	Aug 1/86	Apparatus and Process for Recovery of Hydrocarbons from Inorganic Host Materials (W. Taciuk)
3970	Aug 5/86	Gaseous and Solvent Additives for Steam Injection for Thermal Recovery of Bitumen from Tar Sands (D.A. Redford and M.R. Hanna)
4102	Aug 7/86	Process and Apparatus for Thermally Processing Heavy Hydrocarbon-containing Liquids (W. Taciuk)
5278	Mar 18/87	Wet Combustion Process (D.W. Bennion, R.G. Moore and J.K. Donnelly)
6576	Apr 28/87	Additive for Inclusion in a Heavy Oil Reservoir Undergoing Steam Injection (J.B. Hyne and P.D. Clarke)

F) **Mexico Patents**

Patent No.	Date Issued	Patent Title
153182		Process and Apparatus for Thermally Processing Heavy Hydrocarbon-Containing Liquids (W. Taciuk)

G) **Mexico Patent Applications**

Application No.	Date Filed	Patent Application Title
200,744	Mar 24/84	Process for Upgrading a Heavy Viscous Oil (Hydrocarbon) (I. Lutz) (Acres Davy McKee DM International, Inc., Houston)

H) European (EEC) Patents

Patent No.	Date Issued	Patent Title
0-028-666	Apr 6/83	Process and Apparatus for Thermally Processing Heavy Hydrocarbon-Containing Liquids (W. Taciuk) (Belgium, France, Italy, Netherlands, and U.K.)
79,302542.0		(Sweden) (as above)
29-65-154.5		(Germany) (as above)
0076882	Jul 17/85	Two-Phase Flowmeter (1) (D.S. Scott and E. Rhodes)
84.301888.8	Mar 20/84	Process for Upgrading a Heavy Viscous Oil (Hydrocarbon) (I. Lutz) (Acres Davy McKee DM International, Inc., Houston)

I) Argentina Patent Applications

Application No.	Date Filed	Patent Application Title
279,427	Dec 21/79	Process and Apparatus for Thermally Processing Heavy Hydrocarbon-Containing Liquids (W. Taciuk)

J) Romania Patents

Patent No.	Date Issued	Patent Title
78671	Oct 31/81	Process and Apparatus for Thermally Processing Heavy Hydrocarbon-Containing Liquids (W. Taciuk)

K) Turkey Patents

Patent No.	Date Issued	Patent Title
22129	May 13/86	Process and Apparatus for Thermally Processing Heavy Hydrocarbon-Containing Liquids (W. Taciuk)

L) Japan Patents

Patent No.	Date Issued	Patent Title
12,248,916		Process and Apparatus for Thermally Processing Heavy Hydrocarbon-Containing Liquids (W. Taciuk)

22.2 ***Prior Company Patents*** (for which AOSTRA has acquired certain licensing rights)

A) Canadian Patents

	Canadian Patent No.	Date Issued	Date Filed	Related U.S. Patent No.	Patent Titles
1.	1125649	Jan 15/82	Dec 19/79	4234042	Direct Combustion Stimulation of a Producing Well
2.	1118341	Feb 16/82	Sep 14/79	4272487	Indirect Thermal Stimulation of Producing Wells

B) **U.S. Patents**

	U.S. Patent No.	Date Issued	Date Filed	Related Canadian Patent No.	Patent Titles
1.	3964547	Jun 22/76	Oct 29/74	972679	Use of Tar as a Diverter in Steam Operations
2.	4147213	Apr 3/79	–	–	Combustion Air Injection Well
3.	4234042	Nov 18/80	Jun 11/79	1125649	Direct Combustion Stimulation of a Producing Well
4.	4272487	Jun 23/81	Jan 1/79	1118341	Indirect Thermal Stimulation of Producing Wells

Tables

Table 1

Oil Sands Technology and Research Fund
Summary of Funds Committed and Disbursed
As at March 31, 1990

Project	Funds Committed	Prior Years' Disbursements	Disbursements April 1/89 to March 31/90	Balance
Institutional Research				
Alberta Research Council				
— Information Centre — ALIS	$ 6,641,107	$ 5,696,567	$ 798,006	$ 146,534
— Oil Sands Research Centre	29,143,886	27,991,881	1,215,172	(63,167)
— Sample Bank	1,913,301	1,706,140	111,760	95,401
— Regional Geological Program	4,975,280	4,596,876	367,878	10,526
— Hydrocarbon Program	3,301,849	2,864,832	401,897	35,120
— Strategic Research Program	5,944,256	4,423,972	1,447,570	72,714
— Macro Energy Modelling	100,000	51,000	–	49,000
Inventors Assistance Grant	1,329,545	894,211	200,000	235,334
University Contracts	34,089,646	28,948,439	2,373,413	2,767,794
Professorships and Chairs	4,121,109	3,921,494	40,000	159,615
New Graduate Assistance Program	490,000	275,116	211,285	3,599
Post Doctoral Fellowships	348,000	91,040	76,875	180,085
Scholarships and Fellowships	4,790,000	3,245,812	398,076	1,146,112
Lectureship Program	12,000	–	2,764	9,236
ARC Access Program	25,000	16,066	–	8,934
University Access Program	175,000	171,238	(146)	3,908
Program Planning and Evaluation	522,000	365,780	19,276	136,944
Petroleum Recovery Institute	5,589,252	4,587,567	1,000,000	1,685
Centre for Frontier Engineering Research	75,000	75,000	–	–
Computer Modelling Group	1,740,000	660,000	1,000,000	80,000
UNITAR Conference	379,000	193,669	96,140	89,191
UNITAR Management and Operations	209,945	110,092	99,853	–
Completed Projects	2,371,643	2,371,643	–	–
	$ 108,286,819	$ 93,258,435	$ 9,859,819	$ 5,168,565
Mining and Extraction				
Retorting				
— UMATAC	$ 18,752,208	$ 17,752,876	$ 999,332	$ –
Nova/Husky/Canstar	176,700	176,700	–	–
Shell Canada/Solv-Ex	3,500,000	3,272,707	–	227,293
Saskatchewan Research Council	20,000	–	15,000	5,000
Terra Energy-SESA Project	500,000	262,775	113,673	123,552
Tzipa Enterprises-OSTEX Process	100,000	91,375	–	8,625
OSLO Project	4,547,500	1,703,500	2,442,665	401,335
Syncrude Canada Limited	555,000	294,297	187,151	73,552
Monenco	259,253	–	67,665	191,588
Lummus Crest Inc.	1,117,000	–	712,891	404,109
Completed Projects	7,123,283	7,123,283	–	–
	$ 36,650,944	$ 30,677,513	$ 4,538,377	$ 1,435,054

Table 1

Oil Sands Technology and Research Fund
Summary of Funds Committed and Disbursed
As at March 31, 1990

Project	Funds Committed	Prior Years' Disbursements	Disbursements April 1/89 to March 31/90	Balance
In Situ Oil Sands				
Peace River				
— Shell	$ 75,039,351	$ 74,917,423	$ 16,580	$ 105,348
Athabasca				
— Amoco	24,947,108	23,792,526	–	1,154,582
— Amoco/Petro–Canada	17,108,250	15,336,494	1,338,535	433,221
— Canterra	52,861,000	43,114,126	5,220,248	4,526,626
Cold Lake				
— BP	25,596,000	23,947,967	10,105	1,637,928
— BP/Petro-Canada	1,499,250	1,150,150	–	349,100
— Bow Valley Industries	17,772,000	12,971,581	761,256	4,039,163
— Suncor – Ft. Kent	400,000	118,979	–	281,021
Alpha Engineering	6,250	3,100	1,888	1,262
Simtech Consulting	65,900	41,674	18,786	5,440
W.T.C. Water Treatment Project	700,000	375,000	59,818	265,182
Shell Water Treatment Project	892,500	678,297	187,006	27,197
Fekete Thermal Software Program	100,000	97,216	–	2,784
Simons Consulting – Coning Project	96,200	75,203	–	20,997
Maurer Drilling	42,126	42,126	–	–
Engineering Studies Program	500,000	205,392	172,495	122,113
Site Studies	375,000	22,878	22,303	329,819
Peach River Task Force	100,000	–	31,177	68,823
Centre for Frontier Engineering	30,000	–	18,000	12,000
D.C. Poon Consulting	10,000	–	10,000	–
Mazzei Oil and Gas	470,000	–	–	470,000
Completed Projects	9,599,999	9,599,999	–	–
	$ 228,210,934	$ 206,490,131	$ 7,868,197	$ 13,852,606
Underground Access				
Athabasca				
— UTF Project	$ 66,281,947	$ 57,914,768	$ 1,443,614	$ 6,923,565
— Completed Projects	5,108,264	5,108,264	–	–
	$ 71,390,211	$ 63,023,032	$ 1,443,614	$ 6,923,565
Carbonate Trend				
Buffalo Creek				
— Union Oil	$ 31,585,000	$ 31,228,441	$ 57,911	$ 298,648
Completed Projects	308,082	308,082	–	–
	$ 31,893,082	$ 31,536,523	$ 57,911	$ 298,648
Heavy Oil				
Petro-Canada	$ 14,308,046	$ 13,892,449	$ 81,710	$ 333,887
Alberta Energy Company	7,941,500	7,197,233	117,246	627,021
Norcen International	4,850,000	5,293,712	(515,121)	71,409
PanCanadian Petroleum	1,500,000	968,332	70,853	460,815
Completed Projects	239,674	239,674	–	–
	$ 28,839,220	$ 27,591,400	$ (245,312)	$ 1,493,132

Table 1

Oil Sands Technology and Research Fund
Summary of Funds Committed and Disbursed
As at March 31, 1990

Project	Funds Committed	Prior Years' Disbursements	Disbursements April 1/89 to March 31/90	Balance
Enhanced Recovery Conventional Oil				
Vikor Resources Ltd.	$ 4,900,000	$ 4,230,008	$ (126,283)	$ 796,275
Hudson's Bay Oil & Gas	2,462,500	2,081,377	144,777	236,346
Robinson Slim Tube Test	169,240	155,990	–	13,250
Canterra's Solids Disposition Project	155,240	116,119	37,877	1,244
Saskatchewan Research Council	150,000	75,000	75,000	–
Westgrowth Petroleums Ltd.	600,000	556,500	–	43,500
PRI EOR Initiatives Program	400,000	343,673	26,462	29,865
PRI Multi-Client Study	20,000	–	–	20,000
Gulf Canada Resources Ltd.	907,283	269,094	501,279	136,910
Bumper Horizontal Well	250,000	250,000	–	–
Pfizer Rundell Horizontal Well	800,000	–	–	800,000
Todd Dietrich Chase Inc.	35,370	–	32,595	2,775
Strategic Research EOR	300,000	–	7,700	292,300
Completed Projects	1,033,391	1,033,391	–	–
	$ 12,183,024	$ 9,111,152	$ 699,407	$ 2,372,465
Bitumen Upgrading				
Residue Utilization Project	$ 1,398,232	$ 1,199,981	$ 16,023	$ 182,228
VEBA OEL – Cold Lake	3,307,042	3,307,042	–	–
VEBA OEL – Athabasca	1,500,000	1,151,019	350,715	(1,734)
HRI	1,656,200	1,586,658	–	69,542
Coal – Oil Processing	50,000	24,774	(16,406)	41,632
Petro-Canada/CANMET Project	450,000	–	392,201	57,799
Partec Lavalin/CANMET/China Project	100,000	–	50,000	50,000
R.T.M. Engineering Ltd.	25,500	–	23,093	2,407
S.F.A. Pacific Inc.	14,306	–	14,306	–
Completed Projects	17,944,566	17,944,566	–	–
	$ 26,445,846	$ 25,214,040	$ 829,932	$ 401,874
Technology Handling				
Database Administration	$ 4,153,515	$ 3,818,741	$ 311,959	$ 22,815
AOSTRA Journal	539,773	441,721	42,340	55,712
Patent Costs	1,070,000	712,872	211,702	145,426
AOSTRA Publication Series	136,700	15,495	41,897	79,308
AOSTRA Technical Handbook	100,000	36,349	55,148	8,503
AOSTRA 15 Year Review	615,000	–	612,177	2,823
Technology Transfer and Commercialization	530,000	201,974	323,753	4,273
Completed Projects	91,865	91,865	–	–
	$ 7,236,853	$ 5,319,017	$ 1,598,976	$ 318,860
Training Activities	$ 2,735,000	$ 2,182,119	$ 440,325	$ 112,556
International Activities	$ 2,150,800	$ 1,850,172	$ 178,880	$ 121,748
Authority Costs	$ 2,732,500	$ 2,232,724	$ 228,811	$ 270,965
Totals	$ 558,755,233	$ 498,486,258	$ 27,498,937	$ 32,770,038

Table 2

Oil Sands Technology and Research Fund
Statement of Revenue
Expenditure and Funds Balance

Fifteen-Year Summary
For the years ended March 31

	1990	1989	1988
Revenue			
Alberta General Revenue Fund	$ 29,349,000	$ 26,100,000	$ 26,900,000
Alberta Heritage Savings Trust Fund	5,151,000	9,900,000	20,800,000
Technology Sales	664,347	774,027	1,325,060
	$ 35,164,347	$ 36,774,027	$ 49,025,060
Expenditures			
Institutional Research			
Alberta Research Council			
— Information Centre — ALIS	$ 798,006	$ 714,129	$ 699,180
— Oil Sands Research Centre	1,215,172	1,312,005	1,430,990
— Sample Bank	111,760	144,000	153,423
— Regional Geological Program	367,878	497,521	464,075
— Hydrocarbon Program	401,897	388,600	374,383
— Strategic Research Program	1,447,570	1,586,666	1,588,050
— Macro Energy Modelling	–	–	17,000
Inventors Assistance Grant	200,000	274,750	109,000
University Contracts	2,373,413	2,864,891	3,018,722
Professorships and Chairs	40,000	743	91,120
New Graduate Assistance Program	211,285	201,518	65,750
Post Doctoral Fellowships	76,875	22,500	22,500
Scholarships and Fellowships	398,076	419,280	418,639
Lectureship Program	2,764	–	–
ARC Access Program	–	5,896	723
University Access Program	(146)	(2,930)	(95)
Program Planning and Evaluation	19,276	39,160	–
Petroleum Recovery Institute	1,000,000	700,000	700,000
Centre for Frontier Engineering Research	–	25,000	25,000
Computer Modelling Group	1,000,000	220,000	220,000
UNITAR Conference	96,140	23,475	104,588
UNITAR Management and Operations	99,853	110,092	–
Completed Projects	–	–	–
	$ 9,859,819	$ 9,547,296	$ 9,503,048

1987	1986	1985 and Prior	Total
$ 34,700,000	$ –	$ –	$ 117,049,000
31,400,000	50,000,000	301,449,032	418,700,032
1,227,125	2,156,404	13,466,808	19,613,771
$ 67,327,125	$ 52,156,404	$ 314,915,840	$ 555,362,803

$ 591,097	$ 499,620	$ 3,192,541	$ 6,494,573
1,972,980	3,015,466	20,260,440	29,207,053
155,588	157,118	1,096,010	1,817,899
517,955	309,345	2,807,979	4,964,753
773,341	797,636	530,872	3,266,729
1,249,256	–	–	5,871,542
17,000	17,000	–	51,000
82,562	117,119	310,780	1,094,211
2,952,754	2,869,781	17,242,292	31,321,853
411,389	493,856	2,924,385	3,961,493
7,847	–	–	486,400
–	22,500	23,540	167,915
336,883	411,063	1,659,948	3,643,889
–	–	–	2,764
1,213	3,476	4,758	16,066
8,697	17,975	147,592	171,093
54,243	66,216	206,161	385,056
1,000,000	1,125,562	1,062,005	5,587,567
–	25,000	–	75,000
220,000	–	–	1,660,000
65,605	–	–	289,808
–	–	–	209,945
67,984	341,252	1,962,408	2,371,644
$ 10,486,394	$ 10,289,985	$ 53,431,711	$ 103,118,253

Table 2

Oil Sands Technology and Research Fund
Statement of Revenue
Expenditure and Funds Balance

Fifteen-Year Summary
For the years ended March 31

	1990	1989	1988
Mining and Extraction			
Retorting			
— UMATAC	$ 999,332	$ 1,004,649	$ 1,378,265
Nova/Husky/Canstar	–	–	33,152
Shell Canada/Solv-Ex	–	–	428,807
Saskatchewan Research Council	15,000	–	–
Terra Energy-SESA Project	113,673	192,389	70,386
Tzipa Enterprises-OSTEX Process	–	81,457	9,918
OSLO Project	2,442,665	1,365,720	337,780
Syncrude Canada	187,151	294,297	–
Monenco	67,665	–	–
Lummus Crest Inc.	712,891	–	–
Completed Projects	–	16,695	–
	$ 4,538,377	$ 2,955,207	$ 2,258,308
In Situ Oil Sands			
Peace River			
— Shell	$ 16,580	$ 175,484	$ 113,028
Athabasca			
— Amoco	–	–	(27,148)
— Amoco/Petro-Canada	1,338,535	1,372,878	2,069,863
— Canterra Energy Ltd.	5,220,248	6,641,372	8,700,700
Cold Lake			
— BP	10,105	13,971	82,402
— BP/Petro-Canada	–	–	–
— Bow Valley Industries	761,256	884,225	841,980
— Suncor – Fort Kent	–	–	–
Alpha Engineering	1,888	2,100	1,000
Simtech Consulting	18,786	9,043	4,299
W.T.C. Water Treatment Project	59,818	34,599	340,400
Shell Water Treatment Project	187,006	–	678,297
Fekete Thermal Software Program	–	97,216	–
Simons Consulting — Coning Project	–	75,203	–
Maurer Drilling	–	42,126	–
Engineering Studies Program	172,495	186,274	19,118
Sites Studies	22,303	22,878	–
Peace River Task Force	31,177	–	–
Centre for Frontier Engineering	18,000	–	–
D.C. Poon Consulting	10,000	–	–
Completed Projects	–	–	–
	$ 7,868,197	$ 9,557,369	$ 12,823,939

1987	1986	1985 and Prior	Total
$ 1,182,251	$ 2,460,548	$ 11,727,162	$ 18,752,207
121,129	22,420	–	176,701
2,843,900	–	–	3,272,707
–	–	–	15,000
–	–	–	376,448
–	–	–	91,375
–	–	–	4,146,165
–	–	–	481,448
–	–	–	67,665
–	–	–	712,891
890,685	1,598,408	4,617,495	7,123,283
$ 5,037,965	$ 4,081,376	$ 16,344,657	$ 35,215,890
$ 12,299,010	$ (1,572,687)	$ 63,902,587	$ 74,934,002
5,432	(47,191)	23,861,434	23,792,527
3,953,698	2,013,365	5,926,690	16,675,029
3,299,311	3,063,138	21,409,605	48,334,374
2,589,985	2,692,069	18,569.539	23,958,071
35,349	281,730	833,070	1,150,149
2,833,056	2,397,730	6,014,591	13,732,838
37,883	(9,284)	90,380	118,979
–	–	–	4,988
9,442	18,890	–	60,460
–	–	–	434,817
–	–	–	865,303
–	–	–	97,216
–	–	–	75,203
–	–	–	42,126
–	–	–	377,887
–	–	–	45,181
–	–	–	31,177
–	–	–	18,000
–	–	–	10,000
19,045	108,218	9,472,737	9,600,000
$ 25,082,211	$ 8,945,978	$ 150,080,633	$ 214,358,327

Table 2

Oil Sands Technology and Research Fund
Statement of Revenue
Expenditure and Funds Balance

Fifteen-Year Summary
For the years ended March 31

	1990	1989	1988
Underground Access			
Athabasca			
— UTF Project	$ 1,443,614	$ 3,091,270	$ 3,764,839
— Completed Projects	–	–	–
	$ 1,443,614	$ 3,091,270	$ 3,764,839
Carbonate Trend			
Buffalo Creek			
— Union Oil	$ 57,911	$ 80,747	$ 255,743
— Completed Projects	–	–	–
	$ 57,911	$ 80,747	$ 255,743
Heavy Oil			
Petro-Canada	$ 81,710	$ (176)	$ (29,809)
Alberta Energy Company	117,246	774,287	165,875
Norcen International Ltd.	(515,121)	(548,382)	(1,188,165)
PanCanadian Petroleum	70,853	207,119	66,140
Completed Projects	–	–	–
	$ (245,312)	$ 432,848	$ (985,959)
Enhanced Recovery Conventional Oil			
Vikor Resources Ltd.	$ (126,283)	$ 931,941	$ (22,200)
Hudson's Bay Oil & Gas	144,777	236,523	277,211
Robinson Slim Tube Test	–	32,382	116,049
Canterra's Solids Disposition Project	37,877	16,869	18,037
Saskatchewan Research Council	75,000	65,000	10,000
Westgrowth Petroleums Ltd.	–	–	(43,500)
PRI EOR Initiatives Program	26,462	343,673	–
Gulf Canada Resources Ltd.	501,279	–	269,094
Bumper Horizontal Well	–	250,000	–
Todd Dietrich Chase Inc.	32,595	–	–
Strategic Research EOR	7,700	–	–
Completed Projects	–	–	–
	$ 699,407	$ 1,876,388	$ 624,691

1987	1986	1985 and Prior	Total
$ 11,248,413	$ 15,691,395	$ 24,118,850	$ 59,358,381
–	–	5,108,264	5,108,264
$ 11,248,413	$ 15,691,395	$ 29,227,114	$ 64,466,645
$ 2,860,676	$ 2,234,802	$ 25,796,472	$ 31,286,351
137	307,439	506	308,082
$ 2,860,813	$ 2,542,241	$ 25,796,978	$ 31,594,433
$ 314,067	$ 316,747	$ 13,291,622	$ 13,974,161
585,204	422,242	5,249,625	7,314,479
6,914,180	17,664	98,415	4,778,591
145,688	99,194	450,192	1,039,186
–	–	239,672	239,672
$ 7,959,139	$ 855,847	$ 19,329,526	$ 27,346,089
$ 484,889	$ (698,262)	$ 3,533,640	$ 4,103,725
129,714	1,437,929	–	2,226,154
7,559	–	–	155,990
81,213	–	–	153,996
–	–	–	150,000
600,000	–	–	556,500
–	–	–	370,135
–	–	–	770,373
–	–	–	250,000
–	–	–	32,595
–	–	–	7,700
2,875	1,476	1,029,040	1,033,391
$ 1,306,250	$ 741,143	$ 4,562,680	$ 9,810,559

Table 2

Oil Sands Technology and Research Fund
Statement of Revenue
Expenditure and Funds Balance

Fifteen-Year Summary
For the years ended March 31

	1990	1989	1988
Bitumen Upgrading			
Residue Utilization Project	$ 16,023	$ 17,475	$ 161,169
VEBA OEL – Cold Lake	–	554,381	2,384,530
VEBA OEL – Athabasca	350,715	3,668	1,147,351
HRI	–	145,855	–
Coal – Oil Processing	(16,406)	24,774	–
Petro-Canada/CANMET Project	392,201	–	–
Partec Lavalin/CANMET/China Project	50,000	–	–
R.T.M. Engineering Ltd.	23,093	–	–
S.F.A. Pacific Inc.	14,306	–	–
Completed Projects	–	36,984	–
	$ 829,932	$ 783,137	$ 3,693,050
Technology Handling			
Data Base Administration	$ 311,959	$ 122,285	$ 240,945
AOSTRA Journal	42,340	38,320	46,185
Patent Costs	211,702	110,252	102,620
AOSTRA Publication Series	41,897	5,695	9,800
AOSTRA Technical Handbook	55,148	31,130	5,000
AOSTRA 15 Year Review	612,177	–	–
Technology Transfer & Commercialization	323,753	157,866	44,108
Completed Projects	–	–	–
	$ 1,598,976	$ 465,548	$ 448,658
Training Activities	$ 440,325	$ 380,107	$ 42,364
International Activities	$ 178,880	$ 167,161	$ 77,930
Authority Costs	$ 228,811	$ 217,867	$ 298,554
	$ 27,498,937	$ 29,554,945	$ 32,805,165
Excess of Revenue over Expenditures	$ 7,665,410	$ 7,219,082	$ 16,219,895
Fund Balance at Beginning of Period	$ 21,712,199	$ 14,493,117	$ (1,726,778)
Fund Balance at End of Period	$ 29,377,609	$ 21,712,199	$ 14,493,117

1987	1986	1985 and Prior	Total
$ 210,187	$ 255,100	$ 556,050	$ 1,216,004
368,131	–	–	3,307,042
–	–	–	1,501,734
1,440,803	–	–	1,586,658
–	–	–	8,368
–	–	–	392,201
–	–	–	50,000
–	–	–	23,093
–	–	–	14,306
7,892,461	4,396,543	5,618,578	17,944,566
$ 9,911,582	$ 4,651,643	$ 6,174,628	$ 26,043,972
$ 498,062	$ 480,930	$ 2,476,518	$ 4,130,699
45,310	149,749	162,158	484,062
15,730	62,851	421,419	924,574
–	–	–	57,392
–	219	–	91,497
–	–	–	612,177
–	–	–	525,727
–	–	91,865	91,865
$ 559,102	$ 693,749	$ 3,151,960	$ 6,917,993
$ 219,758	$ 270,129	$ 1,269,762	$ 2,622,445
$ 71,687	$ 109,690	$ 1,423,705	$ 2,029,053
$ 448,223	$ 471,612	$ 796,468	$ 2,461,535
$ 75,191,537	$ 49,344,788	$ 311,589,822	$ 525,985,194
$ (7,864,412)	$ 2,811,616	$ 3,326,018	$ 29,377,609
$ 6,137,634	$ 3,326,018	–	–
$ (1,726,778)	$ 6,137,634	$ 3,326,018	$ 29,377,609

Auditor's Report
and
Financial Statement

Alberta Oil Sands
Technology and Research Authority
Oil Sands Technology and Research Fund
Financial Statements
March 31, 1990

Auditor's Report

Balance Sheet

**Statement of Revenue,
Expenditure and Fund Balance**

**Notes to the
Financial Statements**

AUDITOR'S REPORT

To the Members of the Alberta Oil Sands Technology and Research Authority

I have examined the balance sheet of the Alberta Oil Sands Technology and Research Authority - Oil Sands Technology and Research Fund as at March 31, 1990 and the statement of revenue, expenditure and fund balance for the year then ended. My examination was made in accordance with generally accepted auditing standards, and accordingly included such tests and other procedures as I considered necessary in the circumstances.

In my opinion, these financial statements present fairly the financial position of the Fund as at March 31, 1990 and the results of its operations and the changes in its financial position for the year then ended in accordance with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

Donald D. Salmon

FCA
Auditor General

Edmonton, Alberta
June 15, 1990

Alberta Oil Sands Technology and Research Authority
Oil Sands Technology and Research Fund

Balance Sheet

As At March 31, 1990

	ASSETS	**1990**	**1989**
Current:			
Cash		$ 35,991,145	$ 26,577,835
Deposits on projects, net (Note 3)		915,595	1,581,362
Accounts receivable		3,740,614	2,028,942
		$ 40,647,354	$ 30,188,139

LIABILITIES AND FUND BALANCE

Current:		
Accounts payable	$ 10,224,549	$ 7,487,205
Holdbacks payable	1,045,196	988,735
	11,269,745	8,475,940
Fund balance	29,377,609	21,712,199
	$ 40,647,354	$ 30,188,139

The accompanying notes are part of these financial statements.

Alberta Oil Sands Technology and Research Authority
Oil Sands Technology and Research Fund

Statement of Revenue, Expenditure and Fund Balance

For the Year Ended March 31, 1990

	1990	*1989*
Revenue:		
Contributions by the Province of Alberta:		
—General Revenue Fund	29,349,000	26,100,000
—Alberta Heritage Savings Trust Fund	5,151,000	9,900,000
Technology sales	664,347	774,027
	35,164,347	36,774,027
Expenditure:		
Institutional research	9,859,819	9,547,296
In situ oil sands	7,868,197	9,557,369
Mining and extraction	4,538,377	2,955,207
Technology handling	1,598,976	465,548
Underground access	1,443,614	3,091,270
Bitumen upgrading	829,932	783,137
Enhanced recovery	699,407	1,876,388
Training activities	440,325	380,107
Authority costs	228,811	217,867
International activities	178,880	167,161
Carbonate trend	57,911	80,747
Heavy oil	(245,312)	432,848
	27,498,937	29,554,945
Excess of revenue over expenditure for the year	7,665,410	7,219,082
Fund balance at beginning of year	21,712,199	14,493,117
Fund balance at end of year	$ 29,377,609	$ 21,712,199

Alberta Oil Sands Technology and Research Authority
Oil Sands Technology and Research Fund

Notes to the Financial Statements

March 31, 1990

Note 1 Authority

The Alberta Oil Sands Technology and Research Authority operates under the authority of the Oil Sands Technology and Research Authority Act, Chapter 0-6, Revised Statutes of Alberta 1980.

Note 2 Significant Accounting Policies And Reporting Practices

Expenditures are stated net of recoveries arising from agreements with various participants. Interest earned on cash balances is credited to the General Revenue Fund, and is not reflected in these financial statements. A statement of changes in financial position is not provided as disclosure in these financial statements is considered to be adequate.

Note 3 Deposits On Projects

This amount represents the net excess of cash calls on projects over actual expenditures.

Note 4 Potential Recoveries

The following amounts represent maximum potential future recoveries from the participants in respect of projects funded by the Authority:

	1990	1989
Shell Canada Resources Limited (In situ oil sands)		
—PRISP Project	$ 12,200,000	$ 12,200,000
—Sale of 50% interest in PRISP Project	12,200,000	12,200,000
Norcen International Ltd. (Heavy oil) — BODO Steam Pilot Project	4,779,000	5,290,000
Vikor Resources Ltd. (Enhanced recovery) — Joffre Project	4,104,000	4,200,000
	$ 33,283,000	$ 33,890,000

Recovery of these amounts is dependent on generation of sufficient revenue by the projects. Due to the uncertainty concerning the amounts of recoveries which may ultimately be generated, these amounts have not been included as a receivable in these financial statements and will be offset against expenditures in the year of receipt.

Note 5 Commitments

The Authority had outstanding commitments as at March 31, 1990 totalling $32,770,000 (1989 $36,903,000) for approved projects.

Note 6 Contingent Liabilities

The Authority is involved in a number of legal proceedings. Claims amounting to approximately $57,000,000 have been filed against the Authority. In the opinion of management, the disposition of these claims is not likely to materially affect the financial position of the Authority. Settlements, if any, will be reflected as expenditure in the year the settlement occurs.

Note 7 Administration Costs

The following costs incurred in the administration of the Authority have been borne by the General Revenue Fund and are not reflected in these financial statements.

	1990	1989
Salaries and wages	$ 2,146,443	$ 2,063,691
Rental of property and equipment	386,254	373,295
Employee benefits	333,990	302,650
Fees and commissions	227,943	246,040
Travelling and hospitality	174,274	198,815
Materials and supplies	75,063	92,745
Freight, express and postage	19,421	19,907
Telephone and telegraph	16,318	15,851
Equipment maintenance	12,607	16,647
Staff relocation costs	11,511	33,300
Insurance premiums	4,521	3,935
Grants	3,050	7,450
Furniture and equipment purchases	2,351	16,735
Advertising	(1,168)	9,171
	$ 3,412,578	$ 3,400,232

Note 8 Approval Of Financial Statements

These financial statements were approved by management.